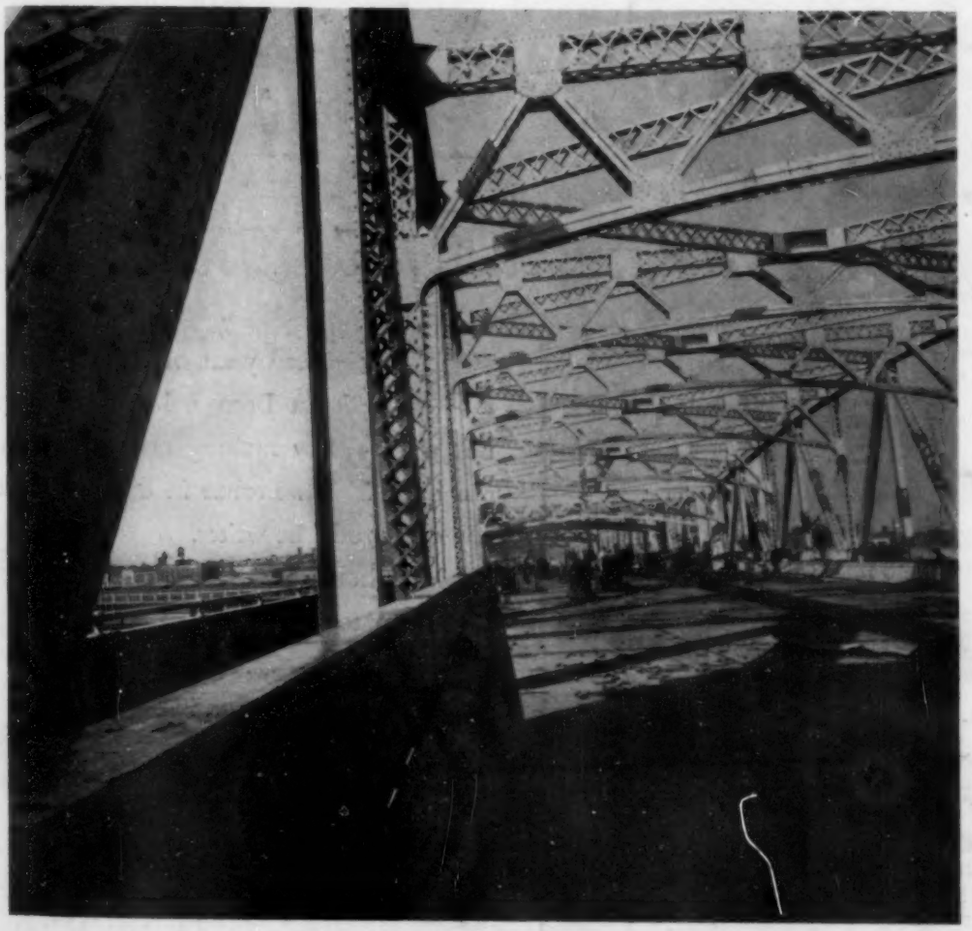
t Engrs.
Library

JUL 28 1936

THE AMERICAN WELDING SOCIETY JOURNAL

VOLUME 15 JULY 1936 NUMBER 7



PUBLISHED MONTHLY FOR THE ADVANCEMENT
OF THE SCIENCE AND ART OF WELDING

Mr. W. I. Reynolds and his Standard Machine Works, Boulder, Colorado.

Better for difficult jobs

...says Colorado welder of TOBIN BRONZE

W. I. REYNOLDS
MERLE REYNOLDS

STANDARD MACHINE WORKS

COMPLETELY EQUIPED FOR EVERY JOB
1011 Walnut Street Phone 1146
BOULDER, COLO

THE AMERICAN BRASS CO.,
Waterbury, Conn.

Gentlemen:

I can build Tobin Bronze in difficult places better than any other rod. We use it for welding malleable steel and iron castings in the automotive industry and believe it to be one of the most reliable welding rods on the market.

(Signed)

W. I. Reynolds

AFTER eighteen years of actual welding experience with Tobin Bronze, Mr. W. I. Reynolds praises this original low melting point bronze rod highly. "I can build Tobin Bronze in difficult places better than any other rod," he writes.

Throughout the country, good welders agree that it pays them to use good rod stock. Thousands of them use Tobin Bronze... identified as genuine by the name stamped every 12 inches in each rod.

ANACONDA
from mine to consumer
REG. U.S. PAT. OFF.

THE AMERICAN BRASS COMPANY

General Offices: Waterbury, Connecticut

Offices and Agencies in Principal Cities

In Canada: ANACONDA AMERICAN BRASS LTD., NEW TORONTO, ONT.

ANACONDA WELDING RODS

THE
AMERICAN WELDING SOCIETY
JOURNAL

WM. SPRARAGEN, Editor | VOL. 15 | NO. 7

JULY

Contents

Technical Papers, Items and Reports

Page

Welded "Battledeck" Floor for New York's New Tri-Borough Bridge (Courtesy Lincoln Electric Co.) ..... Front Cover

The Effect of Welding on Design, by *T. McLean Jasper* 2

Jigs and Fixtures for Resistance Welding Machines, by *H. C. Cogan* 9

22-Inch Gas Line Arc Welded 15

Protective Appliances, by *Thomas A. Willson* 16

Bronze-Welded Monel Metal, by *O. C. Jones* 18

The Determination of the Quality of Fusion Welded Joints, by *E. R. Fish* 19

Design of Welded Trusses, Part II, by *Andrew Vogel* 22

Portable Welding Shop, by *J. C. Carter* 26

Welded Steel Truck Frames for B. M. T. Lines Multi-Section Cars, by *G. D. Spackman* 27

Design of Welded Steel Structure, by *Robt. E. Kinkead* 30

Current Welding Literature 31

Society and Related Activities

Tentative Program Seventeenth Annual Meeting 32

The Welding Industry 34

Midwest Welding Conference 34

Specification for Railway Bridges 34

Obituary 34

Section Activities 34

ISSUED MONTHLY

AMERICAN WELDING SOCIETY

PUBLICATION OFFICE
20th and Northampton Sts.,
Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th St.,
New York, N. Y.

OFFICERS FOR 1935–36

President: J. J. Crowe
Treasurer: C. A. McCune
Senior Vice-President: E. R. Fish
Secretary: M. M. Kelly

Divisional Vice-Presidents
A. G. Leake, New York & New England
T. C. Smith, Pacific Coast
W. W. Reddie, Middle Eastern
C. L. Eksergian, Middle Western
E. E. Dillman, Southern Division

SECTION HEADQUARTERS

PHILADELPHIA
Engineers' Club, 1317 Spruce St.
CHICAGO
608 South Dearborn St.
PITTSBURGH
Room 906, House Building
NEW YORK
33 West Thirty-Ninth St.
NORTHERN NEW YORK
General Electric Co., Schenectady, N. Y.
CLEVELAND
2261 East 14th Street
SAN FRANCISCO
Pare Ave. & Halleck St., Emeryville, Cal.
LOS ANGELES
8976 San Miguel Ave., South Gate
BOSTON
Engineering Societies of New England
715 Tremont Temple
WESTERN NEW YORK
500 Morgan Bldg., Buffalo, N. Y.
DETROIT
Paramount Welding Supply Co.
5950 Second Blvd.
PORTLAND, ORE.
P. O. Box 1899, Station F
MARYLAND
516 N. Charles Street
MILWAUKEE, WIS.
2841 N. 51st Street

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication, provided proper credit is given.

Copyright, 1936, by the American Welding Society

Subscription $4.00 per year in United States and possessions; $4.50 in Canada, Foreign Countries, $5.50.

Entered as second-class matter January 15, 1932, at the post-office at Easton, Pa., under the Act of March 3, 1879.

The Effect of Welding on Design*

By T. McLEAN JASPER†

The Effect of Welding on Design

THE perfection of welds, which consistently equal or surpass the physical properties of the plates joined, has had a profound influence on the design of present-day pressure vessels and other important structures. It not only made possible better designs of lighter weight with equal safety, but it should also be given credit for bringing about these great advancements.

Welding Obsoleted Established Design Practices

Before the advent of modern welding, joints could be made only by splicing or overlapping the plates, which usually were held together by means of bolts or rivets. Therefore, the joint was the weakest point in the structure and, in the case of pressure vessels, justified the custom to base the safety factor on the strength of the longitudinal seam in the cylinder. This basis of design has become so habitual with designing engineers, that they find it difficult to accept the full value of the welded joint and to take advantage of it for making improvements in design. However, the several codes of good practice, which have been developed during the last few years to govern the activities in welding work, have done much to advance the proper utilization of this new tool in many fields. As a result, welding is today being applied to nearly every type of engineering structure.

Welding is no longer to be classed as an art, but has become a practical and reliable tool of industry, the use of which is guided by well-defined rules and sound practices. It enables the engineer to design for butt joints of autogenous material as ductile, tough and strong as the material in the rest of the structure. In other words, the joint has ceased to be the point that controls the safety of the structure; this concern should be transferred to the shape of heads, reinforcement of openings, proper distribution of metal, etc. Yet, the tendency has largely been to substitute welding for riveting or bolting without consideration of the possibilities and significance that the new joint offers. Designers would do well to readjust their methods along the above lines in order to reap the full benefits in increased safety or greater economy that are available to them.

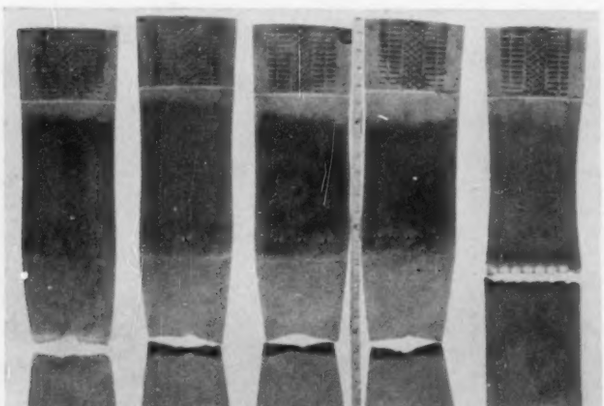


Fig. 1—Tensile Test Specimens Cut across a Weld Joining 6-in. Thick Plates. Specimens Were Machined All Over to Assure a Uniform Section. The Section Area through the Weld Was Reduced in Various Amounts by Drilling Holes as Shown. With 5 Holes (16% Reduction of Area) the Specimen Still Broke Outside the Weld

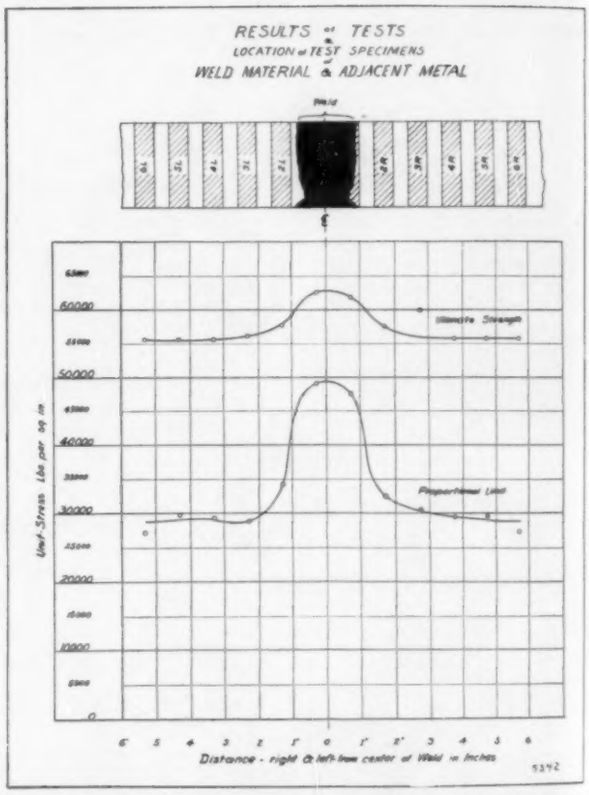

RESULTS of TESTS
LOCATION of TEST SPECIMENS
WELD MATERIAL & ADJACENT METAL
Weld
Ultimate Strength
Proportional Limit
Unit Stress Lbs per sq in
Distance - right & left from center of Weld in Inches

Fig. 2—Test Results on Specimens from Welding Plates, 2⅝-in. Thick, Showing That the Weld and the Adjacent Metal Is Stronger Than the Original Plate. Test Specimens Were Cut at 1-in. Intervals Parallel to the Weld and Pulled in the Same Direction

Advantages Offered by Welding

The effect of welding in the pressure vessel industry was to reduce weight about 25%, still maintaining the same safety. If the designer were reluctant to take advantage of the opportunity to reduce weight, the result obviously was that the structure as a whole had a greater fundamental factor of safety. The same principles of design improvement, that welding was instrumental in developing for the pressure vessel industry, can to advantage be applied to nearly every type of engineering structure—for reduction of weight or increase of the fundamental safety factor. Examples of modern structures, which have materially benefitted from the

* A contribution for the proposed Welding Handbook of the AMERICAN WELDING SOCIETY. Constructive criticism is invited.

† A. O. Smith Corporation, Milwaukee, Wisc.

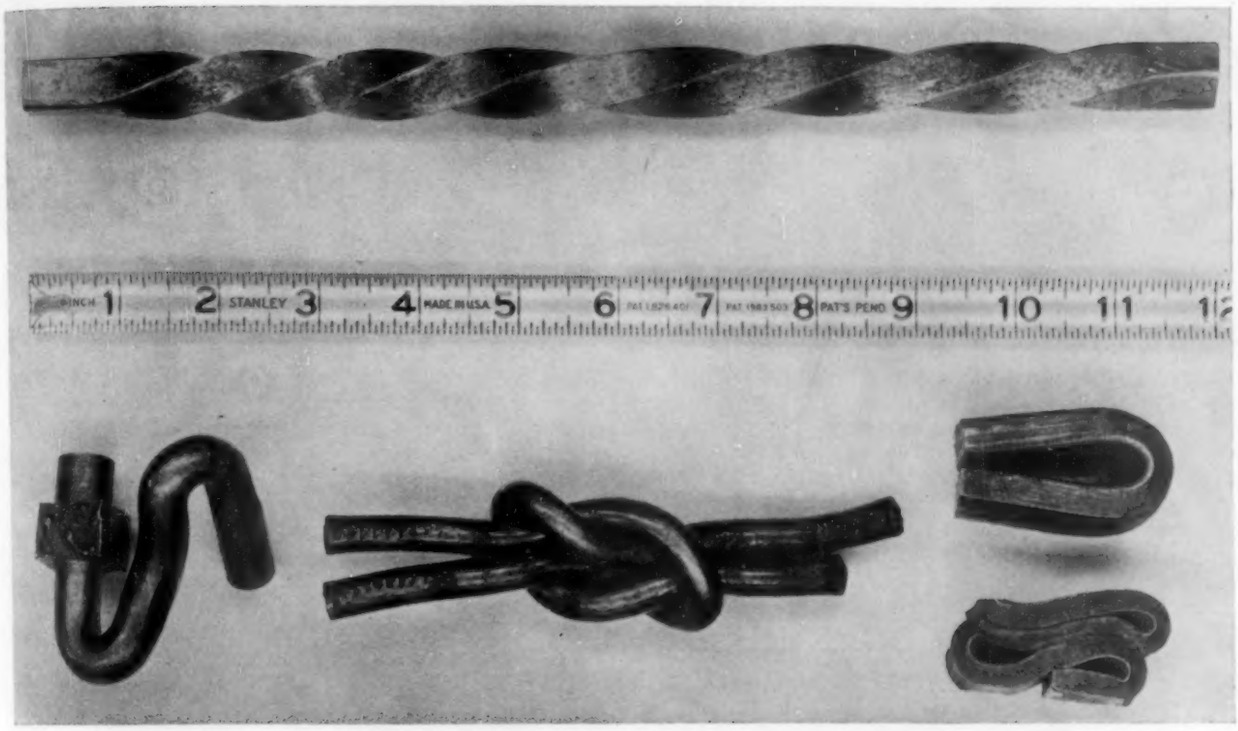


Fig. 3—Weld Specimens, Which Have Been Deformed Cold without Previous Heat Treatment, Showing a High Degree of Ductility

application of welding in their design and manufacture, range from airplanes to locomotives, from bridges to boilers and from machinery parts to tanks and pipe, etc. Numerous other constructions owe their very existence to the fact that joints in steel can now be made, without overlapping, that are as strong, tough and ductile as the steel joined.

Besides their main advantages there are many others having to do with wider choice of material, ease of fabrication, reliability of testing and freedom in the design as well as size of the structures. Still other advantages are more indirect. For instance, welding has had a very searching effect upon the production of quality steels. Although, at first, commercial steels were superior to commercial welding, the situation was soon reversed due to intensive study. Instead of the welding being blamed for a poor joint, it then became apparent that the quality of the steel could be a factor in the results of welding. Today, commercial welding steels have been brought to such a high degree of excel-

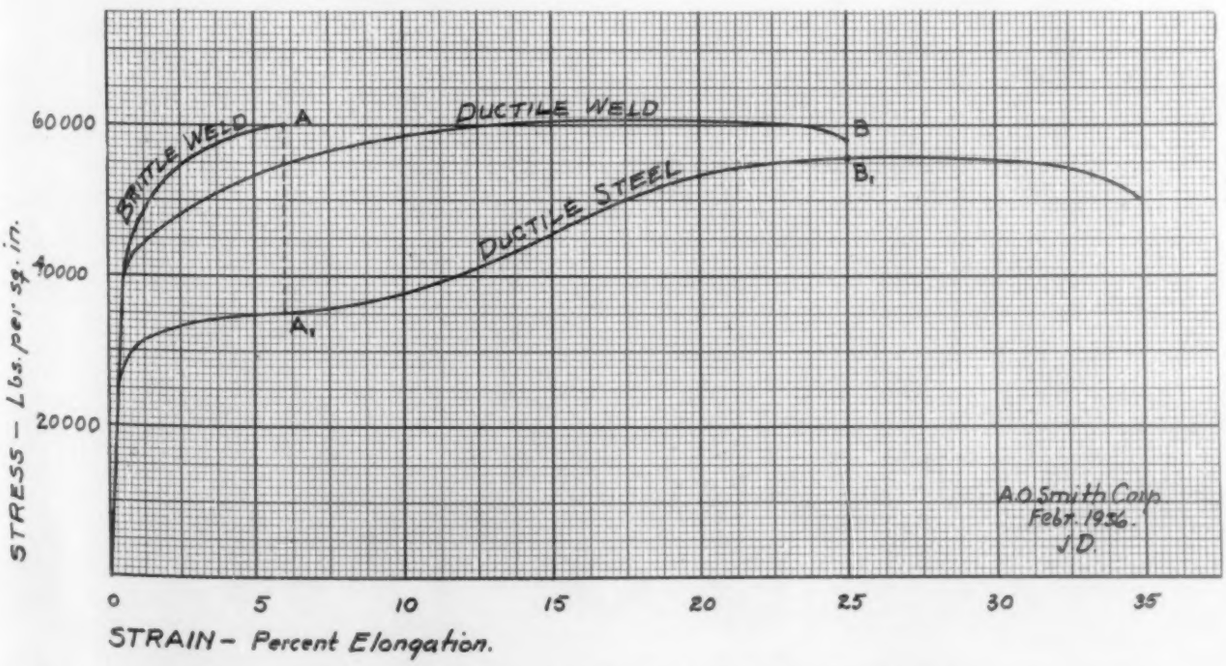


Fig. 4—Typical Stress-Strain Diagram for a Ductile Steel, a Ductile Weld and a Brittle Weld

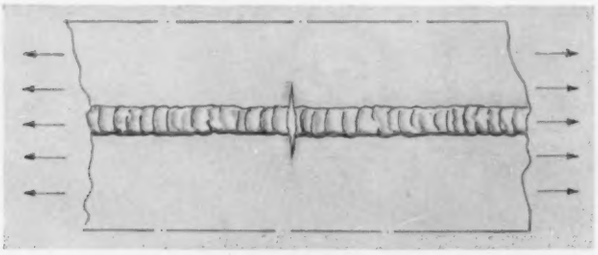


Fig. 5—The Type of Failure That Is Likely to Occur with a Brittle Weld Joining a Ductile Steel, When Stressed in a Direction Parallel to the Weld

lence, due to the generous cooperation of the steel mills, that both the steel and the welding contribute to the quality of the joint. The steel producer should be given due credit for this assistance in bringing welding to its present status of development.

With the correct design of weld rod and the proper application of welding technique, nearly every commercial steel used in quantity can be welded with the assurance that the joints will have physical properties equivalent to those of the parent metal. Such welds are composed of a superior steel, due to the second refining which takes place when going through the arc. It is a steel, which will better resist corrosion and which is tougher and finer than a comparable steel made in a large tonnage furnace. Thus, the designing engineer of today has available in welding a method of construction, which has advanced far beyond the most ambitious expectations, and which bids fair to give him complete freedom in his work.

The Design of Proper Welds

Certain structures, such as bridges which are subject to severe impact loads, call for welds having good energy absorbing qualities. In other words, only ductile welds should be used for ductile steel structures, etc. It is a good rule, therefore, that the proper weld be so designed that its characteristics (strength, ductility, toughness, etc.) are substantially equal to or even slightly better than those of the steel welded. With correct weld rod, expert welding technique and known steel, this can very readily be accomplished. In applying welding, the designing engineer, therefore, need only specify appropriate requirements covering the welds of his structure.

That welds of predetermined characteristics can be produced consistently is proved by the fact alone that over one million tons of welded steel products for a variety of services have been produced to date by the company with which the author is associated. The following test results will serve to substantiate the foregoing:

Strength, coupled with adequate proportions of other necessary weld qualities, is demonstrated in Fig. 1. These pull-test specimens were cut at right angles to the weld jointing 6-in. thick steel plates. Holes, 0.2 in. in diameter, were drilled through the weld, as indicated in the picture, for the purpose of successively reducing the section area of the weld in the specimens. The results of the test show that the weld metal was at least 16% stronger than the plate steel. It should be noted that, due to adequate weld ductility, the stress intensification at the drill holes evidently was adjusted when

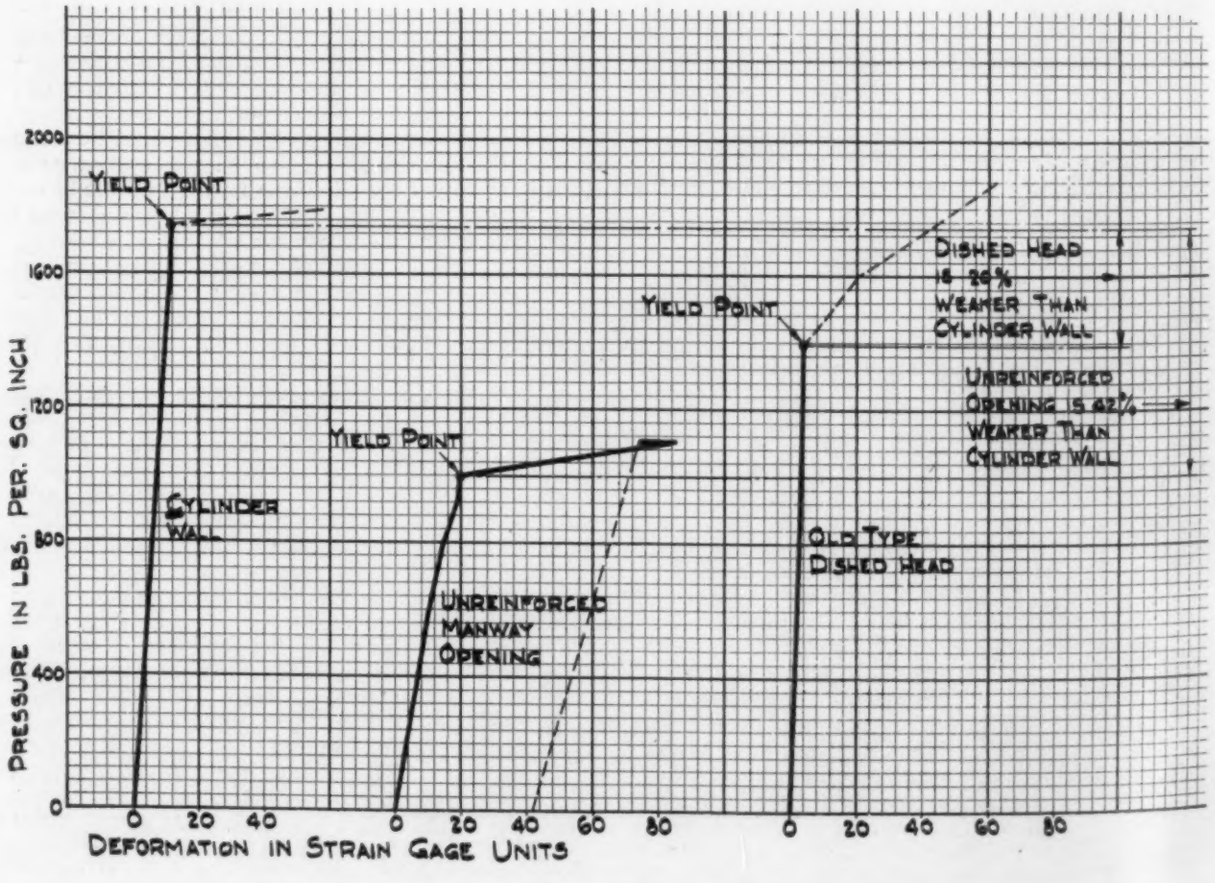


Fig. 6—Curves Showing Lack of Uniformity in the Strength of a Vessel with Dished Heads and Unreinforced Openings. These Test Results Were Obtained Simultaneously during One Pressure Test. The Stress in the Metal Was the Same at Each Test Point When the Yield Point Was Reached

the yielding point of the weld was reached. This shows that a ductile weld can accommodate itself to the steel being welded thereby protecting the structure in service.

Figure 2 graphically illustrates similar findings from tests made on specimens cut parallel to the weld joining $2^{5}/_{8}$-in. steel plates. Each point on the curves represents a test bar the full thickness of the plate and on 1 in. spacing. The area thus covered extends 6 in. to each side of the weld. The curves for ultimate strength and yield point show gradual increases through the areas adjacent to the weld, reaching their peaks in the center of the weld.

Ductility of a high degree is illustrated in Fig. 3 by several specimens, which had not been heat treated but were tested as welded. The specimen, twisted in a spiral, has the weld across its center. Note the slightly different degree of twist in the weld area. The reason for this is explained by the higher yield point of the weld metal as indicated in Fig. 2. All the other specimens shown are made entirely of weld metal.

Toughness of the weld as compared to that of the plate material is indicated by the following typical results of Charpy impact tests on the same steels as used for the test illustrated by Figs. 1, 2 and 3. The average value obtained on the standard key-hole bar is 25 foot-pounds for the plate material, and 30 foot-pounds for

Fig. 7—Test to Destruction of This Vessel Showed That the Unreinforced Opening Was the Weakest Point. Failure Occurred at a Stress Value in the Cylinder Equivalent to 60% of the Ultimate Strength of the Steel

Fig. 8—Test to Destruction of a Vessel with Reinforced Openings but Having a Short Knuckle Radius Dished Head. Failure Occurred at a Stress Value in the Cylinder Equivalent to 80% of the Ultimate Strength of the Steel

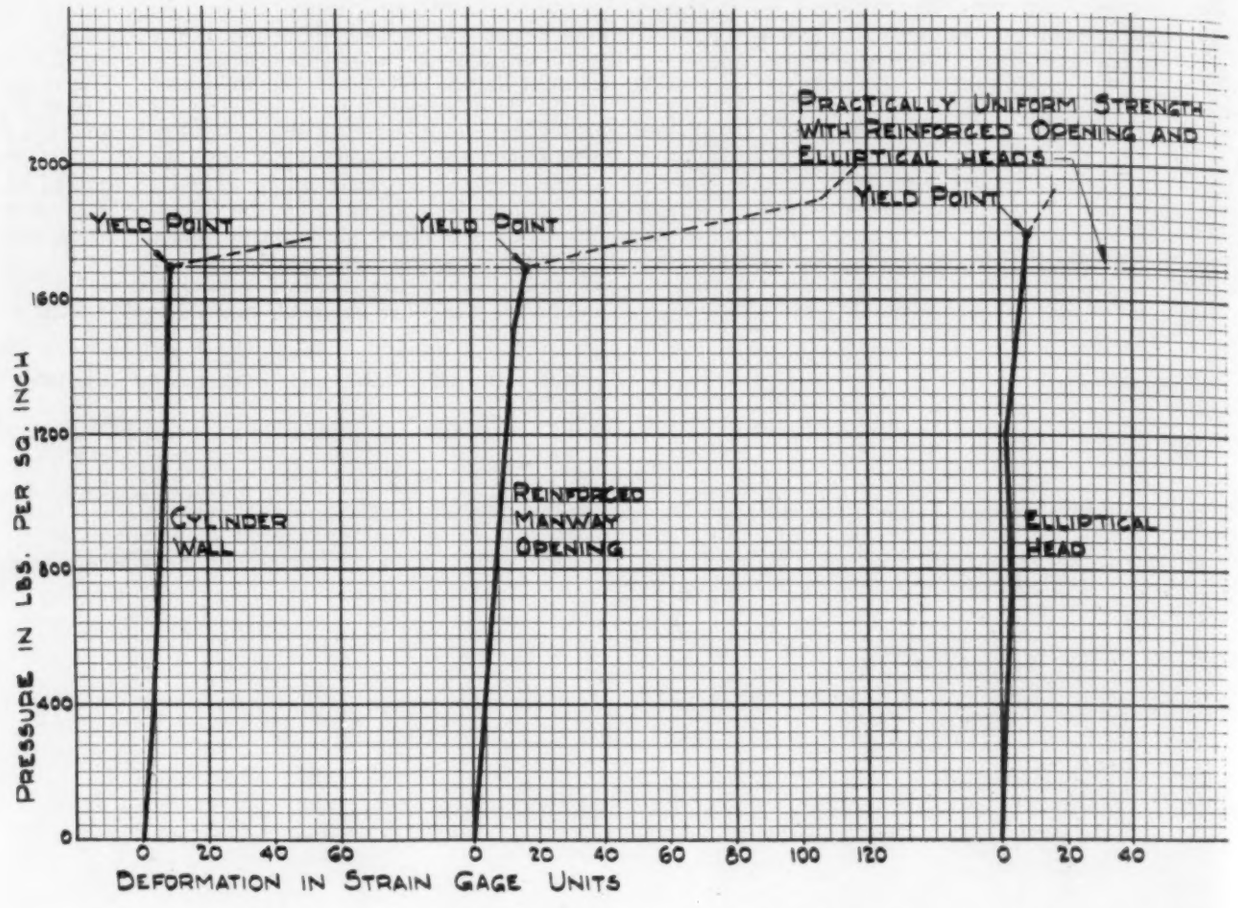


Fig. 9—Curves Showin Uniform Strength in a Vessel When Ellipsoidal Heads and Reinforced Openings Are Used

the properly designed weld. The values obtained for the weld junction and the adjacent metal were somewhere between the above-mentioned two values.

It might be well to again emphasize the importance of proper welds. While small inequalities in characteristics between the weld and the plates welded can be accommodated, serious consequences may result from poorly designed welds. For instance, failure can occur in a strong but brittle weld before the plate material has reached a stress much above the yield point. Why this can happen is explained by Fig. 4, which is a stress-strain diagram for a ductile steel, a ductile weld and a brittle weld. As an example, consider a condition which frequently exists, where a weld joining two plates is stressed in a direction parallel with the joint. The strain on the weld will then be the same as on the plates, and, if brittle, the weld material cannot elongate as much as the plate material. The result is that the weld may reach its breaking strength when the plate steel is stressed only to a little over half of its ultimate strength. This is indicated by points A and A', respectively. In other words, if the structure is designed with a theoretical safety factor of 4, based on the strength of the steel as indicated by pull specimens of the plate and the weld separately, then the real safety factor would still be only a little over 2. Should the strain be allowed to reach point A, the weld would fail as indicated in Fig. 5 due to lack of ductility but not for lack of strength. Needless to say, such a fracture has a tendency to progress once it is started.

However, had the weld been of proper ductility—again referring to Fig. 4—the strain in the structure could be carried to points B and B', before failure occurred. In this case, the full strength of the structure would be utilized and the stress at failure would equal the ultimate strength of the steel.

Relieving Weld Stresses

When extremely hot metal is deposited in the groove between plates to be joined, it has a localized effect on the steel, which, unless properly handled, will create undesirable conditions. Strains or stresses are developed by the shrinkage of succeeding layers as they are deposited and may accumulate to dangerous proportions in heavy welds, if they are not reduced or eliminated. There are two general methods for relieving such weld stresses—by peening each layer as it is deposited, or by appropriate heating.

If the correct amount of peening is applied and that can be established by experiments, the stresses in each layer can be completely removed. When the next layer is deposited the arc will melt off the undesirable surface effects caused by the peening hammer, and the last layer need not be peened.

Stresses can also be removed by heating to a temperature which must not be so high that the shape of the structure is changed, nor so low that, to be effective, the treating time becomes too long. It has been found that 1150° F., applied for one hour per inch of thickness of the main members, will satisfactorily meet average conditions.

Either one of these methods, or a combination of the two for very thick welds, will produce the desired relief of stresses according to the findings from many years' experience. This experience has particularly shown the need for relief of stresses in very thick-walled structures. The dividing line at which stress relief can be dispensed with is a matter for the various codes to establish. It is also apparent that there is no choice of method for stress relief in the case of certain structures such as bridges. In these cases it is relatively easy to determine the amount of peening necessary to obtain adequate relief. In some instances, circumstances make local heating advisable, but very great care need be exercised lest the results will be worse than if no heat treatment had been attempted.

The codes for the highest class of pressure vessels require a final heat stress relief of the completed structure even if peening has been applied throughout the construction. This gives the utmost assurance of complete stress relief, but there are many types of heavy steel construction where this procedure is out of the question. For instance in shipbuilding it would be impossible to heat treat the whole structure and then it is all the more important that the peening method is carefully and correctly applied. In the case of other large structures, where comparatively thin, ductile material is used, it may not be necessary to apply any stress relieving method. The stresses developed by the welding are then of such a low value that they can be overlooked same as is generally done with the stresses set up by the cold forming of thin steel.

Designs for Welding

In the application of welding to designs, the aim should be to duplicate the safety that long experience and good engineering has indicated to be necessary in each case. The factors of safety used on many structures are factors applied to certain locations only. Oftentimes these locations were selected more for the ease with which stress calculations could be made at that point than it was because this was the location for the highest stress. That this situation was quite generally acknowledged is indicated by the frequent reference to the factor of safety as the "factor of ignorance," particularly in the pressure vessel field. Such a term need no longer be applicable, since welding has brought about the use of correct shapes and proper reinforcements. This results in vessels of more nearly uniform strength throughout and a dependable safety factor. Many other engineering structures gain the same point by the use of welding and the application of correct design principles.

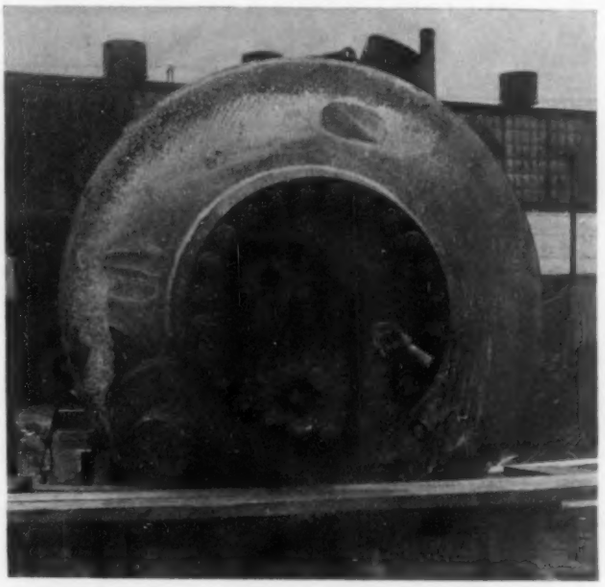


Fig. 11—Non-Destructive Test Method, Employing Lime Wash, Used on a Vessel with a Dished Head. The Short Knuckle Radius Yielded First as Shown by the Flaking of the Lime

Figures 6–10, inclusive, serve to illustrate this point. The first shows three curves, representing the conditions of stress at as many critical points on a pressure vessel of the typical design, which has prevailed for many years. Figures 7 and 8 show the types of failure corresponding to the curves. It is well known that the factor of safety is based on the cylinder formula, but, as is seen, this is not the highest stressed location. Of the three points selected for the test, the unreinforced opening was the weakest. As a matter of fact, the safety factor at the opening would be only 3 while the official factor was 5, based on the cylinder. A 40% reduction in the weight of this vessel would leave it just as strong as before, provided it had been properly designed for welding. This claim is substantiated by the curves in Fig. 9, and the possibilities of proper design are indicated by the results of destruction test, pictured in Fig. 10.

Proof Testing to Improve Designs

Proving of designs is a question, which most designing engineers could well afford to consider. It is not always necessary to test designs to failure to gain the objective, nor is it even necessary to test the structures to the point where their value or future usefulness has been

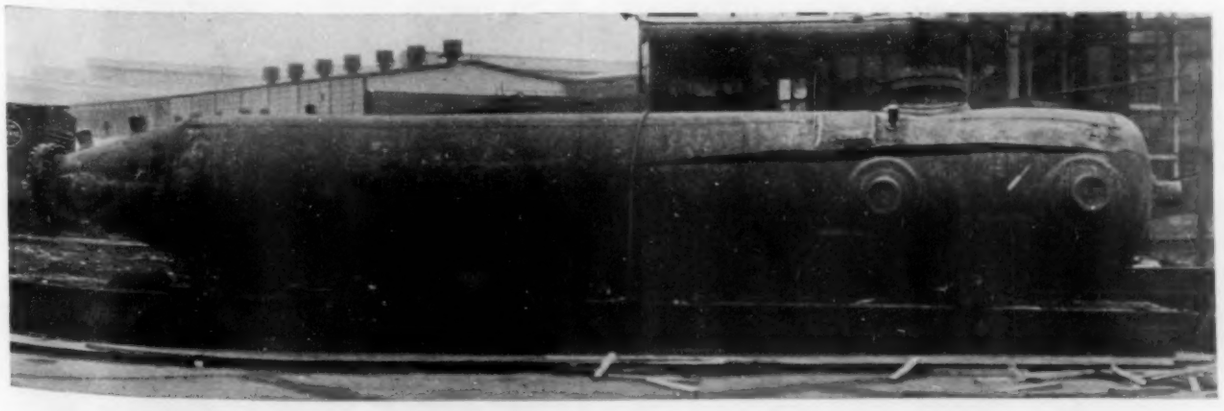


Fig. 10—Test to Destruction of a Vessel Which Is Properly Designed. Failure Occurred at a Stress Value Equivalent to the Full Ultimate Strength of the Steel

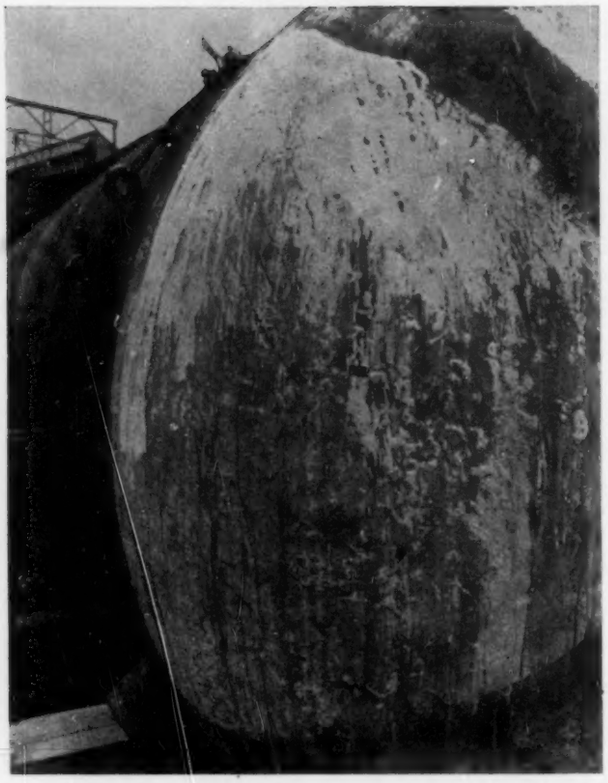


Fig. 12—Lime Wash Test on an Ellipsoidal Head, Showing Freedom from Stress Intensification as Indicated by the Uniform Flaking of the Lime

impaired. Before good welding was available, however, designs could not be easily proved.

A non-destructive test method which has proved very reliable and useful to the author, is being employed in Fig. 11. It consists of covering the parts to be studied with lime wash,* which will flake off at the weakest points first when the load is applied. In this case a dished head is being tested as part of a vessel. The wall thickness was uniform throughout this vessel and, knowing the actual strength of the steel, it is possible to calculate the stresses in the cylindrical portion quite accurately. The picture clearly shows the stress-lines on the head, brought out by the flaking of the lime wash. It is evident that the steel first started to yield in that area and it occurred at a stress, which was only 80% of the known yield strength of the cylinder.

Figure 12 shows the results when the same test was made on an ellipsoidal head (2 to 1 ratio) attached to the same vessel as the dished head. Note that it shows no area of stress intensification. It indicates that this type of ellipsoidal head permits a more balanced design, inasmuch as equal thickness of heads and cylinder would result in a uniform stress condition. Subsequent tests to destruction on both types of heads very clearly demonstrated the superiority of the ellipsoidal head, since vessels equipped with such heads invariably did not fail until the full strength of the steel was reached. The vessel with the conventional dished head eventually failed in that head at about 80% of the cylinder strength as established by tensile tests on the steel used.

As a check on the above tests, strain gage measurements were also taken on the same vessels with the results given in Figs. 6 and 9. This method is, however, not recommended for the reason that the points of maximum stress are hard to locate and because it is a tedious method which might easily give misleading results. It is less expensive and much easier to cover the whole structure with lime wash and look for the flaking.

The lime wash method can be applied with equal success to nearly every type of welded structure. The flaking of the lime will reveal any localized area that may be poorly designed thus enabling the designer to remedy the weakness by proper change of shape or reinforcement at that point. It will also assist him in better balancing future designs resulting in material savings and lasting value at the nominal expense of a few tests.

In this connection it is well to bring up the matter of testing miniature models in lieu of the full-size structures. Sometimes this method may be helpful, but in most cases model testing is worthless, because the action under load by thick sections is very often quite different from that of the same design in smaller scale. This is particularly true for structures made of ductile material in which overstress adjustment can be readily accommodated if the plate is thin but not very well in the full-size thick structure.

Summarizing the Effects of Welding on Design

During the comparatively short period of intensive development to its present status of usefulness and wide acceptance, welding has had a marked effect on Engineering Designs. It was instrumental in revealing poor designs and in improving them. It made possible the elimination of overlapping joints with their obvious weaknesses. It provided the means for dependable leak-proof construction. Finally, it spurred steel manufacturers to keep pace with welding development in improvement of steels for the many Services needed by Industry.

The author has illustrated these effects of welding on design mostly by examples from the pressure vessel field. The same principles are, however, applicable to every branch of engineering design where welded joints can be used. When heeded, these principles will help the designer to utilize welding most efficiently and economically.

Annual Meeting

Your attention is called to the Tentative Annual Meeting Program of the AMERICAN WELDING SOCIETY published elsewhere in this JOURNAL. These technical sessions together with the Metal Congress Exposition afford an unusual opportunity to receive latest up-to-date information on welding progress and developments. Plan to attend.

* The following lime wash consistency has proved most satisfactory: Thoroughly mix 2½ lb. of slaked lime with one gallon of water. Apply with a paint brush one coat only, and allow to dry well before starting the test. If the steel surface is cleaned before applying the lime wash, more sensitive results will be obtained.

Jigs and Fixtures for Resistance Welding Machines*

By H. C. COGAN†

JIGS and fixtures are used on resistance welding machines covering the entire field of resistance welding applications—spot welding, projection welding, butt and flash welding, seam or line welding—and also applications not directly welding operations, but done on standard resistance welding equipment such as, heating and heading over rivets, preheating for various die or assembly operations, and soldering and brazing.

Objects of Jigs and Fixtures

The main object of using jigs and fixtures is identical to their use in drilling, milling and other machine tool operations; that they reduce the cost of welding by obtaining greater production, greater accuracy, the employment of unskilled labor, and many times saving the cost of a special machine.

The modern automobile, refrigerator, household appliances, furniture, etc., would not be possible were it not for the mass production of interchangeable parts on resistance welding machines made possible by the use of jigs and fixtures.

Difference Between a Jig and Fixture

To define a jig and fixture we shall call a "fixture" a work holding and locating device that is bolted or fastened to a standard welder, being a part of the complete machine. A "jig" will be considered an appliance for holding and locating the work but separate from the welder, either loaded and fed to the machine or stationary and the welder being brought to the work, such as a portable spot welding application.

* A contribution for the proposed Welding Handbook of the AMERICAN WELDING SOCIETY. Constructive criticism is invited.
† Chief Engineer, National Electric Welding Machines Company.

Fig. 1

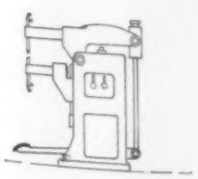
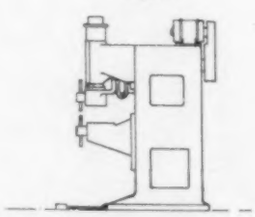


Fig. 2



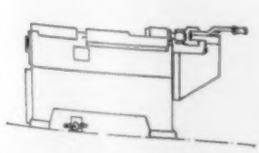


Fig. 3

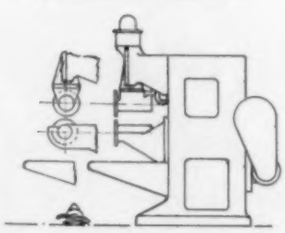


Fig. 4

Type of Machines

Types of Resistance Welding Machines Used

The resistance welding machines used in conjunction with jigs and fixtures are usually standard machines. Figure 1 shows a "Rocker Arm" type, foot operated, spot welder; Fig. 2 shows a "Press Type" Motor Driven Machine; Fig. 3 shows a flash or butt welder, and Fig. 4 shows a seam or line welder. The "Rocker Arm" type spot welder and the hand and foot operated machine are gradually being superseded by the motor-driven Press Type Welder, and the slow butt welder has retired in favor of the motor-driven flash welder which entirely eliminates the human element errors in control.

Both of these modern machines readily lend themselves to the application of jigs and fixtures, dial and hopper feeds, and automatic conveyor assembly lines. The seam or line welder is of two types, circular or end seams, and straight or longitudinal seams, fixtures being applied to both to assist in maintaining and locating a straight seam weld or in holding bulky work.

Methods of Welding

Before a fixture or jig can be designed for or applied to a job, the best possible method of welding the parts must be determined. An operation being done by a repeated single spot welding method may, by a simple change in the parts, be done by the projection welding method where all spots to be welded on the parts can be welded by one stroke of the machine, making for higher production and a better looking finished piece of work. By changing from the slow butt weld to the flash weld less finishing may be required, or a short seam weld on a difficult shape by the use of a mandrel and roller electrode may replace several spot welding operations, using a number of different shaped electrodes. It is always best to thoroughly try various methods of welding the parts *before* a costly jig or fixture is designed and built. The machine available must be suitable for the stock to be welded in kva. capacity and welding pressure. The speed of operation must also be considered.

Welding data for the thickness of stock or number of projections that can be welded by the various methods according to the kva. rating of the machine are available. However, if the machine available is to be speeded up for a faster operation than that for which it was originally built its kva. rating must accordingly be increased, or the maintenance of the welder through replacement of parts and particularly the electrical portion thereof, will more than offset the supposed savings for faster operation through jigs or fixtures, due to the consequent overloading of the machine. Series welding, multi-spot

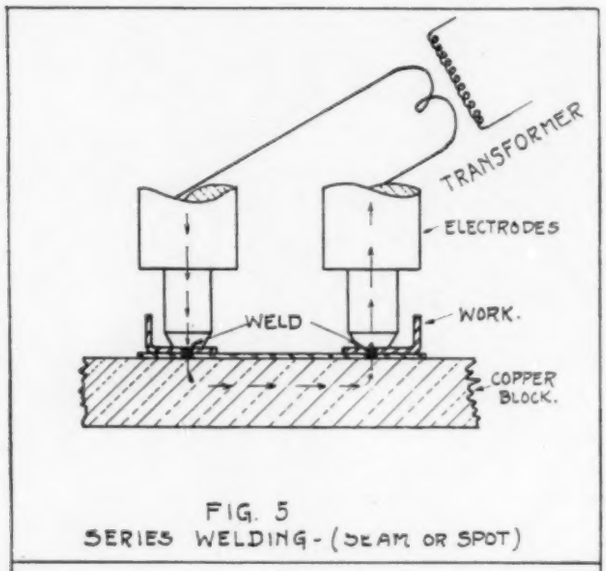


FIG. 5
SERIES WELDING - (SEAM OR SPOT)

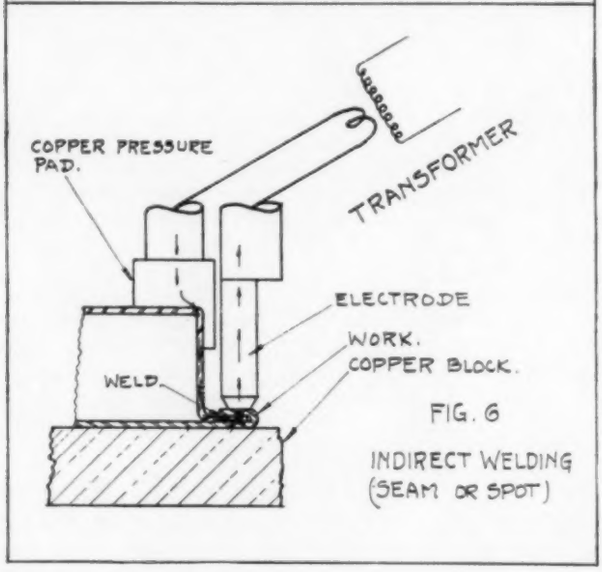
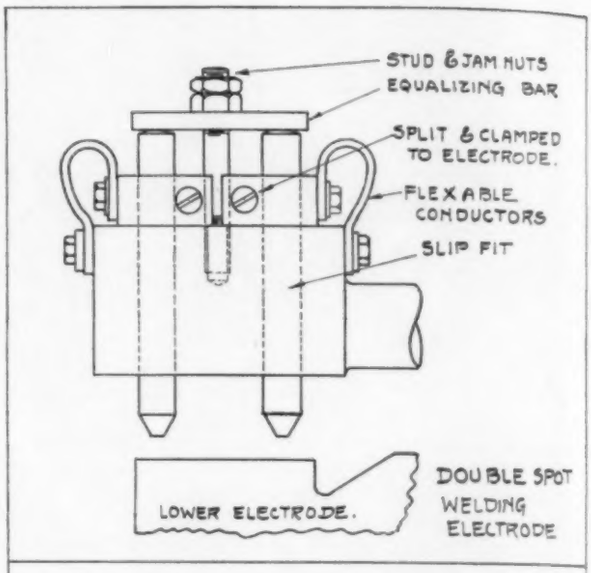


FIG. 6
INDIRECT WELDING
(SEAM OR SPOT)



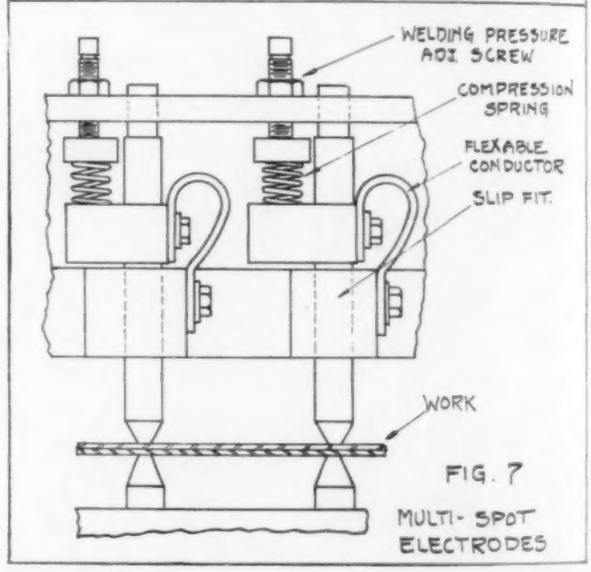


FIG. 7
MULTI-SPOT ELECTRODES

welding, and indirect welding are described under a separate heading.

Materials for Jigs and Fixtures

The correct use of such materials as tungsten copper or its equivalent, the several grades of alloy copper, aluminum bronze, aluminum, and aluminum alloys and non-magnetic cast iron, also insulation materials in their different grades and methods of insulating for protection from electrical current primarily but also to resist flash particles thrown off the stock when welding, water, dirt and handling protection cannot be fully described here. There are, however, these data available and the designer should be familiar with these materials and use them in their proper places.

Tungsten copper is a material indispensable for facing electrodes particularly used for flash and projection welding. It is used as a facing to copper electrode bodies and is usually silver soldered to the electrode bodies, making a complete one-piece electrode. It is many times more durable than copper and because its conductivity is lower, must be generously water cooled.

Alloy copper is used frequently for spot welding tips, electrodes, and as a body for holding a tungsten copper insert. Its conductivity is higher than tungsten copper and functions better for spot welding tips on some work than the tungsten copper electrode. It is usually five or six times harder than rolled copper and lasts as much longer.

Aluminum bronze is used for fixture bases, arms, clamping devices, stops and such parts of a jig or fixture close to or part of an electrical conductor where greater strength or wear is necessary than could be obtained if brass or copper or other non-ferrous, non-magnetic materials were used.

Aluminum and its alloys are used extensively in jigs where a minimum of weight is necessary. Aluminum is of great value and its use is recommended whenever weight is an important consideration.

Non-magnetic cast iron is used frequently for parts of a jig or fixture close to or in the magnetic field of the welder. It is cheaper than aluminum bronze and slightly stronger than ordinary cast iron. Fixture bases, frames and machine arms are frequently made of this material, sometimes known as "nickel iron."

Copper is mentioned last since it is most familiar and is used as a basis for welding jigs and fixture materials. It occupies as important a place for welding machine jigs and fixtures as iron and steel does for other machine tool operations. Rolled copper in flats and rounds, cast copper, and hammered or forged copper are indispensable. Copper tubes cast into copper castings should be used

wherever possible for water cooling inasmuch as that method is vastly superior to steel tubes cast into copper castings. Drilling copper castings for water cooling frequently causes a lot of expense and delay in obtaining a water-tight casting.

Changes to a Standard Machine

Frequently it is necessary to alter the welding machine in some way to better adapt a jig or fixture for the method of welding desired.

"Rocker Arm" spot welders can easily be changed to do a small butt welding job by replacing the electrodes with simple clamps to hold the work. They can be made to do a short seam welding job by attaching a roll or roll segment in place of the upper or lower electrode or both. They cannot, however, be altered to do a satisfactory flash welding or projection welding job as the mechanical construction of the machine is not suitable.

Motor driven, air or hydraulic operated press type welders can readily be changed to do projection or spot welding by simply altering their electrodes.

It is essential that all projection welding electrodes are located directly on the center line of pressure application, and that the lower arm be of a sturdy construction to avoid deflection. Press type welders cannot be readily converted to do flash welding or seam welding.

Butt and flash welders are readily interchangeable for either operation. Such change is accomplished more through the method of operating than in actual change of the machine structure or controls.

Seam welders (gear driven) can readily be changed for straight and circular seams. They cannot be readily changed to do any other type of welding. Changes to seam welders consist mostly in their adaption to different sizes of work and usually this means only a change in the lower arm and work guiding device.

Rules of Welding Fixture or Jig Design

Before going into a detailed description of some jigs and fixtures a listing of several rules to be followed in their design and construction will be briefly outlined.

RULE 1—Keep all magnetic materials (iron and steel) out of the "loop." By "loop" is meant, in a spot welder, the gap surrounded by the upper and lower arm, the electrodes, and the base of the machine housing the transformer. This gap is an intense magnetic field and any iron or steel placed therein will attract the magnetic lines and become hot, and in some cases actually melts. The presence of iron or steel in the "loop" chokes the available welding or heating current back from the electrodes, making for poor efficiency of the welder. All parts placed in this "loop" or space must be non-magnetic.

RULE 2—Keep this loop or space described above as small as possible. This space, sometimes called throat gap, is the cause of many disappointing results in setting up and installing fixtures, for many times a 24-in. or longer throat machine is used where a 12-in. or even smaller throat could be used to much better advantage. Also over-all height of welding fixtures should be reduced to a minimum. All this again makes for more welder efficiency and makes possible the doing of jobs that may seem too heavy for the machine, eliminating excessive losses due to increased reactance and lowered power factor of the machine.

RULE 3—Make all welding electrodes easily and quickly replaceable and water cool them as close to the tip as possible. In most every case of spot welding fixtures the standard electrode tip can be used. These are readily obtained and inexpensive to replace. The inlet water tube should be large enough to prevent plugging up, even though dirty water is used—$^3/_{16}$ in. to $^3/_8$ in. inside diameter, depending on the job.

RULE 4—Insulate all gage pins, clamps, locators, index pins, etc. In all jigs or fixtures where locating pins touch the work they must be insulated from the work by being pressed into a fiber, bakelite or other insulating material sleeve having projecting shoulders which in turn is pressed into the base of the fixture. When a gage pin or stop touches both pieces of work being welded it should be of aluminum bronze or some similar material, for electric current shunting across the pin has no respect for the hardest of alloy steel and will pit and burn it, whereas a bronze pin will not offer sufficient resistance to cause the current passing through it to arc. This will prevent burns.

RULE 5—Provide sufficient cross section to current carrying members and run as close to the electrodes as possible. Use as few breaks or connections in the circuit as possible. When we consider the characteristics of a welding current we immediately see the necessity for this. A welding current is extremely high in ampere capacity and carries from 3 to 20 volts, depending on the machine and the job, and a pure copper conductor cannot carry more than 1200 to 1500 amperes per square inch and, if water cooled, will carry 1500 to possibly 2000 amperes per square inch. If the conductors are too small overheating will result and the fixture will be useless unless these conductors can be enlarged. And again if a welding fixture were built in sections the loss of current (commonly known as voltage drop) passing from one section to another would be too great to have enough left for welding.

RULE 6—All moving slides, bearings, index pins, adjusting screws and any accurate locating device should be protected from flash. This is particularly necessary on flash welders although on spot or projection welding some flashing is bound to occur and when as many as 200 to 4000 welds are made per hour, flashing can cause a lot of trouble getting across insulated pins, causing a direct electrical short, or into slides, making repairs necessary.

RULE 7—Provide adjustment for electrode wear. Most electrodes for spot welding are pure copper, and after a production run wear down a distance that the stroke of the welder will no longer maintain a welding pressure contact between the electrodes and the work. They then must be adjusted either by raising the entire lower arm or fixture or replacing with refaced or new electrodes. Not only must adjustment of electrodes be provided to maintain a constant welding pressure on the work at all times but stops, gage points, pins, etc., must also compensate or be of a large enough surface to gage the work at both the new and worn out electrode height.

RULE 8—Check welding pressure application. Since the welding pressure application to a piece of work has a direct affect on the weld, the design of a fixture must take into consideration the following: (*a*) accuracy in the machine work for projection welding fixtures and electrodes, and (*b*) the elimination of deflections due to the welding pressure, so that the upper and lower electrodes are parallel with each other in all directions and remain so when final welding pressure is applied. When necessary to projection weld at a slight angle the projections should be elongated in the direction of the possible "slide" that occurs when "squeezing" for the weld. Flash welding clamps must be so designed as to clamp the piece of work with at least twice the final pushup pressure to prevent possible slippage of work and to insure a good electrical contact. The welding height or point where the electrode touches the work in "Rocker Arm" machines to be in a direct horizontal line to the

fulcrum point of the arm so no slipping or wiping of the electrodes on the work will result when pressure is applied.

RULE 9—Ease of operation and protection for operator. As is common to all jigs and fixtures for any machine ease in loading and unloading must be taken into consideration. One feature of a welding fixture that is not common to fixtures for other machines is that a welding fixture must be designed and built to accommodate the loading of usually two or more separate parts that become, after the welding operation, only one piece that must be unloaded. Care must be taken that a welding fixture or jig will unload properly when the parts are welded. The danger to the operator when loading and unloading fixtures and jigs, from the standpoint of electrical shock, is very remote providing there is no primary short in the machine. The secondary current, or welding current, is of very low voltage and is entirely safe even though the secondary circuit is unprotected. However, for the operator's protection only one side of the secondary circuit—either above the top electrode arm or below the fixture base—should be insulated from the base of the machine. The welding machine should also be grounded so if a primary short develops in the transformer or controls, it will be positively grounded through the welding machine and not through the operator, as would be the case if both sides of the secondary circuit were insulated from the machine base and the operator was touching both upper and lower electrodes or electrode supports. Further protection for the operator's hands should be taken into consideration by providing guards on hand loaded electrode dies. The use of two (2) hand operated control switches that must be pressed by the operator's two hands usually is a simple method for absolute safety.

RULE 10—Be sure the fixture or jig is suited to the job and the machine. As stated in a former paragraph all phases of possible welding operations should be considered as well as the machine to be used and the number and size of pieces to be welded. All have a direct bearing on the type of fixture used. When the method of welding is determined, time should be taken to completely check the parts to be welded so as to provide for sufficient electrode surface and clearance. Be sure that the welds are in the best possible position, that the stock specified is weldable, that necessary provisions are made for clamping and gaging, that allowances for flash off are included, and that the correct size and shape of projections, or correct amount of lap is used.

To determine the above several sample welds should

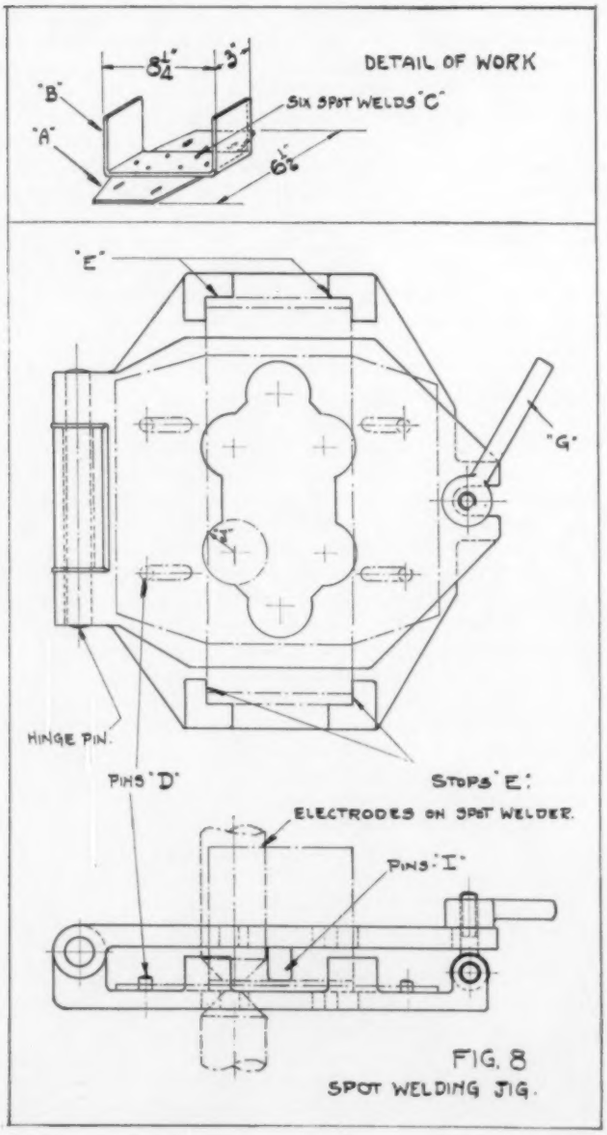


FIG. 8
SPOT WELDING JIG.

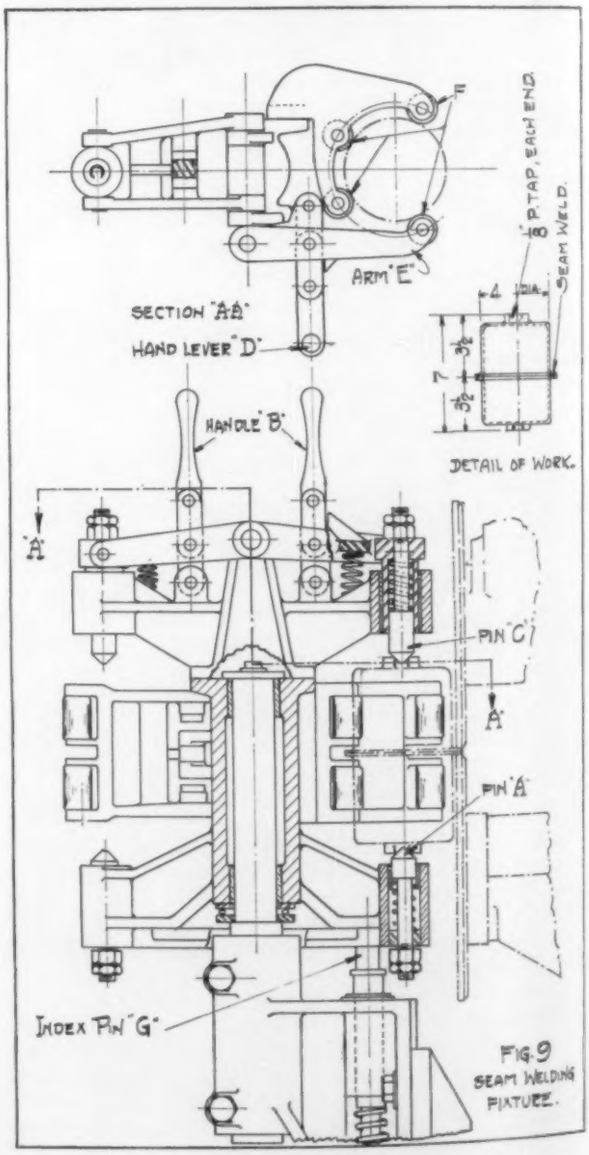


FIG. 9
SEAM WELDING FIXTURE.

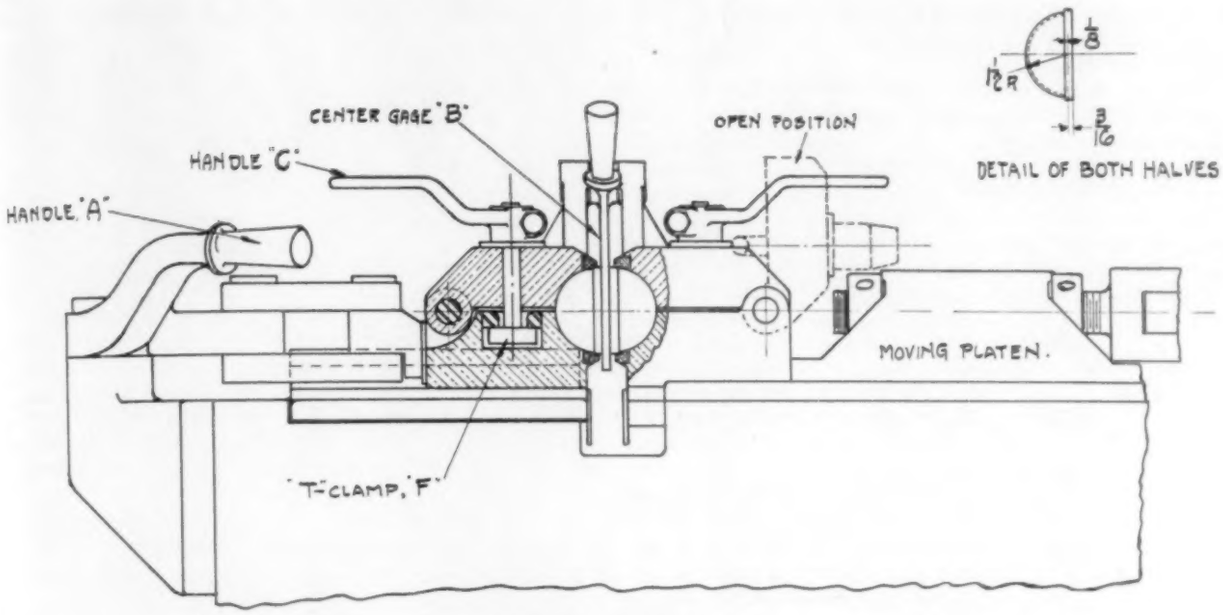


Fig. 10—Flash Welding Fixture

be made, either on the machine to be used with the fixture or jig, or a similar machine, from which sufficient data can be obtained to specify the machine required. Allowances should be made, of course, for the new arrangement and speed of welding.

Welded samples of the job should always be made, wherever possible, and thoroughly tested before the design or construction of a fixture or jig is started.

RULE 11—Provide sufficient water cooling. This very important rule is usually very much neglected and brought forcibly to attention through overheating, excessive electrode wear, transformer burnouts, etc.

On a high production job where electrodes are welding with each stroke of the machine, running continuously, an individual and separate water-cooling line should be provided for each electrode. A sight drain pot should be provided and inspected frequently to insure a flow of cool water. Regulating valves should be provided to adjust this water flow to prevent waste. Various types of water cooling should be considered. The flood system of a constant external flow of water into a drain pan is very efficient, particularly for seam or line welding. Water cooling through troughs cast in the sides of the fixture or fixture support provided much more water-cooled surface than a drilled hole. Cast in copper pipe or tubes in copper castings should be used where various angles or bends of the cooling paths are necessary. The casting of steel tubes into copper castings, for cooling, should be avoided as it is an inferior method. In the case of small jigs to be handled frequently, there should be several provided so they will be used at sufficient time intervals to allow them to cool sufficiently between welds to permit them to be handled. Welding completely under water is always possible but care should be taken to provide a suitable water container to prevent water splashing over on the operator or floor. Also make sure that the work and water is clean, preventing dirt or foreign matter from being carried into the jig or fixture and clog up the faces of the electrodes or contact surfaces. Welding under water has been found of decided advantage in seam or line welding of small diameters where sufficient water cooling could not be provided in the lower arm because of work clearance. Also in dial feeds for projection welding that method has simplified the water circuits considerably.

RULE 12—Knockouts or strippers. In a welding fixture or jig for heavy welding or when the stock may not always be clean, there is a tendency for the work to stick to the electrode faces. This should be taken into consideration where progressive jigs are used, also when automatic or quick loading and unloading of the work is desired. Knockout pins, operated through a leverage advantage or by an air cylinder, or a positive stripper, save considerable production time and add to the operator's protection.

RULE 13—Stationary parts of fixture and work affected by magnetic field of machine. The magnetic pull of a welding machine toward the transformer is frequently of such intensity as to lift small pieces of work out of their locators and small eccentric clamps, made of steel when sufficiently close to the loop to be affected, are sometimes actually released by this force. Work holding plates and clamp handles of non-magnetic material will prevent this condition.

Series, Multiple and Indirect Welding

The above are general rules applying to most fixtures for resistance welding. It would be impossible to cover in detail the design and operation of flash welding clamps and fixtures, projection welding fixtures and locators, etc., as each and every job has its own characteristics and application. We can illustrate only a few and describe them briefly. There are, however, several problems that would result in a ready solution if the less familiar methods of welding were better known. We refer to Series Welding, Indirect Welding and Multiple Spot Welding, any of which method can be applied to a standard welding machine, or at least to a fixture designed with one of the above methods in mind.

The *Series Method* of resistance welding is applicable to spot, projection or seam welding, and is illustrated in Fig. 5. Its application in spot or seam welding is especially desirable whenever possible. Its advantages are: (1) Welding two welds in a piece of work at one machine stroke, or (2) welding two pieces of work where it is

essential that no markings, indentations or discoloration occur, (3) welding with all pressure application on one side of the work, such as large tanks and bodies where otherwise an extremely long throat depth would be required. The welds must, however, be far enough apart to insure the welding current passing through the lower conductor bar instead of the work, usually 1 or 2 inches is a safe minimum to consider.

The *Indirect Method* of welding is usually used where the welding current must pass through the side or ends of a piece of work which, due to its shape or the presence of some sub-assembly on the part before welding, prevents the welding current from going into the work in the conventional manner. Figure 6 illustrates this method being used.

Multiple Spot Welding—Figure 7 shows arrangement for applying multiple spot welding electrodes to a standard machine. It illustrates the equalized pressure arrangement so necessary for the welding of two or more spots at one time. Applications for any number of multiple electrode assemblies can be used depending on their spacing, size and capacity of machine.

Similarity of Welding Jigs and Fixtures to Other Jigs and Fixtures for Other Machine Operations

Clamping arrangements, locating points, general design for quick loading and unloading, weight distribution, etc., all follow along the same lines used for conventional jig and fixture design. Perhaps more in welding than in other machine operations, the operator should, if possible, be able to see the weld as it is being made, since electrode replacement, due to wear, and necessary changes in heat setting, due to voltage fluctuations during the run, are required and must be made by the operator.

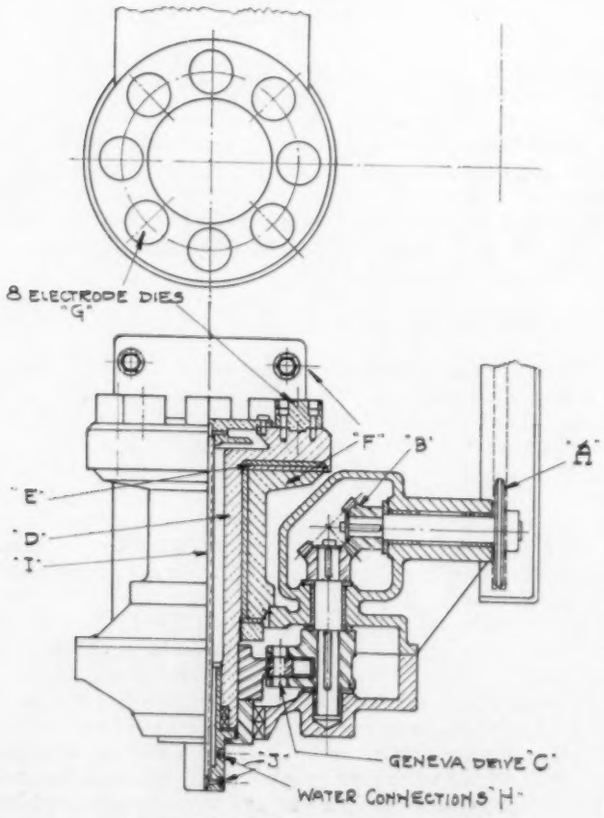


Fig. 11—8 Station Dial-Spot or Projection Welding

Auxiliary Electrical Devices for Fixtures

An electrical control circuit is a part of every resistance welder and this electrical circuit can and should be used extensively for the operation of such devices as solenoid operated valves, and clamping devices, magnetic chucks and hold-downs. Simple magnets (operating on A.C. or D.C. current) built into the welding heads or dies, many times simplify the handling and locating of small parts. Where a large part is placed on a lower die and a comparatively small part to be welded in the center of this piece, a D.C. magnet coil, placed in or around the upper die, will allow loading and gaging this small piece on the bottom of the upper electrode.

Solenoid operated valves for air, water or oil, which in turn actuate feeding or clamping cylinders, operated from pressure or roller limit switches, can produce an entire sequence of difficult clamping and loading operations entirely automatically and can be operated from the main cam or clutch shaft of the motor-driven welder.

Combination of Operations

On many pieces of work the final operation is the resistance welding operation. This has led to the incorporation of the welder or necessary parts thereof into special machines, primarily designed for other operations. Tube rolling machines, assembly machines, turn tables, conveyor sections, use a transformer and pressure application of electrodes and a control, placing these units at the location desired and synchronizing the operation of welding or heating to suit such requirements.

Combinations such as heating and upsetting, heating and cutting off, filling a container just prior to welding the head in place, are many times incorporated in one welding fixture.

Figure 8 illustrates a small spot welding jig for welding together the two parts comprising the base for a fractional horsepower motor. This jig locates the parts accurately for welding and also locates the position of the six spot welds required. The work is done on a standard spot welder without any changes to electrodes or arms.

Referring to Fig. 8 the work is shown in detail and the two parts (*a*) and (*b*) are to be welded by six spots at (*c*). The jig is comprised of a base and a hinged top plate. Part (*a*) is loaded into jig when open and located by placing slots over the four (4) insulated pins (*d*). Part (*b*) is then loaded by placing this part between stops (*e*). The jig is then closed and locked by handle (*g*) and insulated pins (*i*) hold part in place. The jig is then picked up bodily and placed over lower electrodes which for each spot fits radius (*j*). The irregular contour of this hole is in both top and bottom parts of jig. The six welds are then made in sequence, and finished work removed from jig.

In many cases for an operation similar to this, two or more jigs are used so a helper can unload and load while an operator welds the parts.

Figure 9 illustrates a two-station seam welding fixture for welding two halves for a container as shown in the detail of the work. The lower half is loaded on pin (*a*) and the upper half directly on top, with flanges together. Handle (*b*) is then raised and top pin (*c*) holds the top half in place (both these locating pins are spring mounted). Hand lever (*d*) then closes the roller arm (*e*) to a definite stop and rollers (*f*) then maintain concentricity of the two halves during the welding operation. The welding rolls and portions of the welding machine are shown in dotted lines. The entire fixture is mounted on a slide

and with an adjusting screw can be raised or lowered to compensate for roll wear.

The two stations are rotated by hand and through a foot operated index pin (*g*) are located in welding position. This foot treadle is also arranged so that it automatically starts the welding sequence when the index pin locates the station, the welding sequence being the lowering of the upper welding roll which is driven and which in turn revolves the work completing the seam weld. The operator then, ready for indexing to opposite station, presses foot treadle which breaks welding circuit and raises the upper roll.

Figure 10 illustrates a flash welding fixture for a 3-in. diameter spherical shell. The detail of each half is shown. The usual standard hand operated flash welder is used and the fixture consists of a left-hand die mounted on the usual stationary platen, a center gage for alignment of the two halves and the moving platen die. Both dies are split and hinge completely open for loading and unloading.

After placing the two halves of the work in the dies, the dies are swung shut but are not locked. The handle (*a*) then moves the left-hand die against the center gage (*b*) (straightening the toggle links) squaring up the work. The handle (*e*) is then turned 90 degrees and the halves are clamped through a "T" cam (*f*). The moving platen is then moved against center gage (*b*) and when work in this die is squared up it is clamped. The center gage is then raised and the two halves flash welded together, dies opened and work removed.

Figure 11 illustrates a cross section through an eight-station dial. This assembly is mounted on the front of a motor-driven spot or projection welder, and is driven by a shaft extension from the welder clutch box, through a roller chain drive to sprocket (*a*), thence through bevel gears (*b*) and Geneva drive (*c*). The main spindle (*d*) is of copper and commercial alloy copper is used for bushings and contact plates (*e*). One contact plate is fastened to the revolving spindle and one to the lower support casting (*f*) (also made of copper) by flat head screws. The lower electrodes or dies (*g*) are simple in construction and wear space is provided. The water connection stuffing box (*h*) provides for water cooling through inlet (*i*), through center tube, around inside of diameter and returns through outlet (*j*). The bevel gears and Geneva drive are enclosed and run in oil. The Geneva wheel is both clamped and keyed to the spindle.

Generous lubrication is provided between the contact plates and spindle and bushing. The casting (*f*) is directly connected to the welding transformer and the welding current passes through this casting into the lower electrodes through the contact plates (*e*), thence through the work to the upper electrode and back to the welding transformer.

The dial illustrated is for rather light duty. For heavy duty welding the same principles apply, except that a more generous water supply should be provided by means of an outer aluminum cover and top plate completely flooding the dial surface with water, and various dial actuating devices to suit the size of the dial and speed required for the heavy duty operation should also be provided.

22-Inch Gas Line Arc Welded

The illustrations shown below were taken in connection with welding operations on Michigan Gas Transmission Corporation's Line from Indianapolis to Detroit and were furnished by H. C. Price, President, H. C. Price, Inc.

Fig. 1 (Below) and Fig. 2 (Right)—Welding Mississinewa River Crossing

Fig. 3 (Lower Center)—Welding River Crossing Header

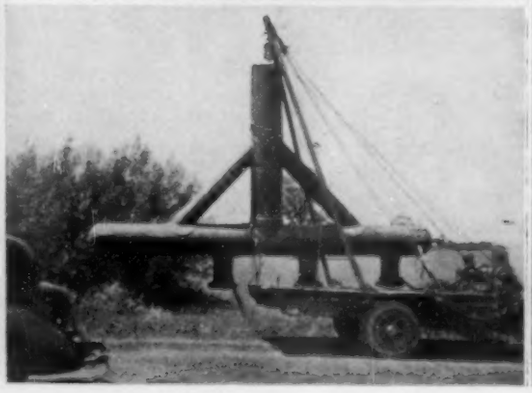


Fig. 4 (Below)—Electric Arc Welding on Michigan Gas Transmission Corporation's 22-Inch Gas Line to Detroit

Protective Appliances*

By THOMAS A. WILLSON†

Part I—For the Eyes

THE appliances required for welding are very essential. No welding job would be complete without a helmet, handshield or a pair of goggles. In most of the publications, very little has been said on protecting the eyes of the operator from excess light that is rich in ultra-violet and infra-red rays. Owing to the fact that the light produced on welding jobs is rich in the ultra-violet and infra-red rays of light, it is necessary to provide the right accessories that will give adequate protection against these hazards of burnt eyes. On all welding jobs, the operator must be able to see the flow of the metal from the electrode that is gradually depositing and building up the same for the joint.

Welding Helmets and Handshields

A great deal of consideration has been given by the Committee on Federal Specifications and, also, a Committee on Safety Standards for the protection of the head, eyes and respiratory organs as specified for use by the Navy. These specifications call for the transmission of the visible light as indicated below:

Shade No.	Max. Tolerance	Standard Value	Min. Tolerance	Temperature ° F.	
3	22.9	13.9	8.6	800–1200	For reflected sunlight from snow, water or for men working near welding jobs but not in direct contact with the work.
4	8.5	5.18	3.3	1200–1600	Viewing furnace work. Stray light from cutting and welding.
5	3.2	1.93	1.2	1600–2000	Light acetylene cutting and welding.
6	1.18	0.72	0.45	2000–2500	Arc welding up to 30 amps; for acetylene cutting and welding.
8	0.162	0.10	0.062	3500–4000	Heavy acetylene welding; also, arc cutting and welding up to 75 amps. Used mostly in handshields.
9	0.060	0.037	0.0230	Over 4000	
10	0.0229	0.0139	0.0087		Arc cutting and welding 75 to 200 amps.
12	0.0032	0.0019	0.0012		Arc cutting and welding 200 to 400 amps.
14	0.00044	0.00027	0.00017		Arc cutting and welding above 400 amps.

Where shades 10, 12 and 14 are used, helmets are usually found more satisfactory.

The welding helmets should be made with good grade of fiber with comfortable, adjustable headgear so that the helmet may be raised with ease and comfort. For some jobs a helmet with a window on which the front can be raised or lowered for inspecting the job is found to be very satisfactory. The helmets should not flare out too wide from the side of the face because if they do it is possible that reflected light will reach the operator's eyes and give a severe burn. In placing the welding glass in the frame of the helmet great care should be taken that it is a proper standard size and that the fiber washer is placed accurately so as to prevent a light leak.

As to the right shade number, it is well to bear in mind that glare must be absent to have a real visible view of the welding scene so that one may follow the electrode all the time. Too much glare blurs the image and tends to blur or confuse the welding scene and the electrode. The operator should be able to follow the line of the job without any difficulty.

In case you ever have any eye burns, you will find that the inflammation produced by the ultra-violet is different from that caused by the high powered infra-red radiation. It has been found that ultra-violet burns will not show up much less than fifteen or sixteen hours after exposure. It has been said that the symptoms of infra-red burns are felt more quickly. Some say that they cause temporary blindness and severe redness of the eyes. All of these difficulties can be eliminated by the use of the proper glass that complies with Federal or Navy Specifications. The eyes, being one of the most delicate organs of the body, should receive important consideration in the welding industry. A one-eyed man does not have the binocular vision that a man has with two healthy strong eyes that have not been burnt.

Welding Goggles

Welding goggles are used mostly for acetylene work and other light welding jobs where the arc does not exceed 30 amperes. When the amperage and heat is so great, then it is necessary to protect the entire face. For this reason, the shades are recommended as shown in the above schedule. The goggles should be light, comfortable and well ventilated. Sometimes the triangular shape goggle fits some faces better than the round shapes. Where correction or prescription spectacles are necessary, a Cover-All is essential because it can be worn very readily over spectacles. To grind a prescription on a welding glass is not satisfactory. Some of the thick parts would make the glass appear dense, when the thin parts would make the glass lighter than that required for the welding job. This variation in density in color would prove to be very uncomfortable to the wearer. There is a vast difference between goggles, and any old type will not help the efficiency of the job.

Special types of goggles, light fiber spectacles and combination welding goggles can be used. A fiber spectacle can be used on extreme light acetylene jobs. The combination welding goggles can be used on railroad work where heavy chipping may be in progress at a nearby point. Most of these jobs are on railroad work.

* A contribution for the proposed Welding Handbook of the AMERICAN WELDING SOCIETY. Constructive criticism is invited.

† Vice-President, Willson Products, Inc.

The ventilation on goggles should be adequate and of such a character as to have the baffles keep out stray welding light from all angles.

References:

Federal Specifications GGG-G-541—Goggles for Welders.
Federal Specifications GGG-S-311A—Handshields, Welders.
Federal Specifications GGG-H-119A—Helmets, Welders.
"Seeing"—Luckiesh and Moss.
"The Effect of Increase of Light on the Visual Acuity of Presbyopic and Non-Presbyopic Eyes"—Ferree, Rand and Lewis.
"Ultra-Violet Radiation"—Luckiesh.
"Light and Shade and Their Application"—Luckiesh.
German Welding Specifications.

Part II—For the Respiratory Organs

The air in the vicinity of welding or cutting operations is rendered unsuitable for respiration by virtue of one or more than one of the following reactions: (1) Poisonous substances may be volatilized by heat; (2) poisonous gases may be generated by the arc or by faulty combustion; (3) oxygen in air may be exhausted.

Poisonous substances such as lead are volatilized when metals covered with lead paint are welded or cut by an electric arc or an oxyacetylene torch. Scrapping of ships which is the outstanding example has caused many severe cases of lead poisoning both in this country and abroad.[1] Poisonous gases, especially nitrogen peroxide, are generated by an electric arc.[2] Recently the death of a welder was attributed to this gas.[3] Nitric oxide is frequently formed by the oxyacetylene flame.[4] Several accidents, one of which was fatal, were recently recorded abroad.[4] Exhaustion of oxygen may occur whenever welding is done in closely confined spaces, particularly if the oxyacetylene torch is being employed.

The welders and other workers in close proximity may be protected against the respiratory hazards described above by one or a combination of more than one of the following methods:

(1) General ventilation of the work place.
(2) Local exhaust ventilation with discharge of fume and gas outside the workroom.
(3) The use of supplied air respirators.
(4) The use of respirators containing both adequate filters and gas absorbing cartridges or canisters.

General Ventilation of Work Places

Welding is carried out today with little regard to ventilation. Machine shops, foundries and similar buildings with high ceilings are generally ventilated by natural means or by roof stacks and ventilators. Where welding is done in moderate amounts on the floors or benches of such buildings, there is rarely a respiratory hazard to anyone but the welder himself. In such cases the welder should wear a respirator.

In a building with a low ceiling, the fumes from welding soon cause a perceptible haze which may increase until conditions become unpleasant. Forced ventilation in conjunction with respirators for the welders will render such air suitable for respiration, but will be more expensive, as a rule, than local exhausts.

While general ventilation reduces the pollution of the air of the entire work shop considerably, it rarely affords ample protection to the welder. This is due to the fact that the fumes from the welding operation rise directly to the welder's face before they have been diluted to a large extent.

Local Exhaust Hoods

Wherever welding is done in large amounts, it is recommended that local exhaust hoods be employed. Hoods held within 6 inches of the welding arc or flame and exhausting to a suitable flue very easily keep the working conditions clean and insure the welder of clean air. A hood 3 by 5 inches, located about 5 inches from the welding operation, requires approximately 200 cubic feet per minute while much less air flow suffices if the hood is brought closer to the arc.[5] Any hood with an air flow such that the velocity at the point of fume and gas generation is 200 feet per minute will collect the fumes and gas very effectively. Exact design or specifications are unnecessary because the failure or success of any exhaust hood is very obvious by sight, particularly in a dark room.

In constructing the modern light cruiser, destroyer and the like, the current practice is to weld most seams, thereby reducing the riveting (also the weight) to a minimum. In such operations local exhaust ventilation is used extensively. For the greater part hoods are not employed because of the inconvenience, but the inlet to a $1^1/_2$ inch corrugated rubber tube is kept very close to the arc and the air is exhausted to the outside by a light and inexpensive rotary blower of the vacuum cleaner type. While such devices do not exhaust all the fumes, they decrease the pollution to a marked extent. In addition to local exhaust ventilation, forced ventilation and respirators are in common use. With this combined system of control, cases of poisoning in ship construction are very rare notwithstanding the fact that most of the welding is done in closely confined quarters.

Wherever practical, local exhaust hoods are desirable because they protect the welder as well as the other workers by eliminating the fumes and gases at the point of generation. Exhaust hoods serve also as an aid in good housekeeping by collecting the fumes before they get into the general atmosphere from which they would slowly settle out about the workshop.

Supplied Air Respirators

It is a general rule in respiratory protection that supplied air respirators, commonly called air line respirators, give the safest and simplest protection possible. A man wearing a good air line respirator can enter any irrespirable atmosphere, providing it does not affect his eyes or do harm by absorption through the skin. Air line respirators may be worn conveniently and comfortably beneath a welding helmet. According to Drinker et al.[5] an air line respirator was worn beneath a welding helmet while welding in an atmosphere made irrespirable by the addition of 15 per cent carbon dioxide and rendered so thick with iron oxide fume that visibility was very poor.

An air line respirator presupposes a suitable supply of clean compressed air which is often not available. If air from a compressed air line is supplied to a man wearing an air line respirator, it should be cleaned by passing through an efficient compressed air cleaner. It is highly recommended that the air to be supplied to air line respirators be compressed by rotary blowers or low pressure compressors in which the air does not come in contact with oil, thus avoiding the possibility of carbon monoxide poisoning.

While not essential, it is important that air line respirators be supplied with a valve in easy reach of the wearer so that he may regulate the air flow to the respirator with ease. In cases where the air is supplied from a high pressure line (60 to 100 pounds per square inch) a valve on the respirator is recommended as a safety feature also.

For welding purposes, the face mask should be of the half mask type so designed that goggles may be worn if necessary. The mask should contact the face fairly well. The exhalation valve must be of ample size to allow easy egress to both the air supplied to the respirator and the air exhaled by the wearer during the period of exhalation. A worker wearing an air line respirator is receiving the proper quantity of air when the exhalation valve shows a slight but definite outflow during the entire period of normal inspiration.

Filter Respirators

Since it has been found[2,4] that poisonous gases are formed in welding and cutting, a filter type respirator must contain both a mechanical filter to take out the fumes or particulate matter and a chemical filter to absorb the harmful gases.

Any of the several respirators now approved by the Bureau of Mines will catch iron, zinc or similar (not lead) oxide fumes, but respirators less carefully made will also suffice. Most welding fumes are readily filtered out and plug filters with great vigor. The mechanical filter should be followed by a chemical filter, such as a chemical cartridge or canister. This chemical filter should contain activated charcoal, or preferably a mixture of activated charcoal and soda lime.

The Bureau of Mines "approved" gas mask canister, designed for protection against acid and organic vapors and smokes, will protect against both fumes and gases from welding, but is needlessly heavy and cumbersome for welding jobs. Abundant practical experience indicates that respirators of the chemical cartridge type with an additional filter before the cartridge will protect welders against any but the most dense atmospheres. Most cartridges supplied with respirators of the chemical cartridge type contain a filter disc as an integral part of the cartridge. Such filters retain a large percentage of the fumes thereby plugging very rapidly. Consequently, the cartridge must be discarded because of resistance to breathing long before the chemical filter is worn out. To avoid this, the respirator should be so designed that an extra filter disc may be employed in front of the cartridge. When the resistance through this filter becomes excessive, it may be replaced by a new filter disc and the cartridge may be used until it is no longer effective.

Respirators of the filter type must afford a close fit between the mask and the face of the wearer. Otherwise there will be an inward leakage of contaminated air due to the suction created within the mask when the wearer inspires.

In most cases it is impossible to wear the usual chemical cartridge respirator beneath a welding helmet owing to the small space between the helmet and the face. To overcome this difficulty, junior size cartridges are being offered to the welding trade but such cartridges contain so little chemical that they must be employed with discretion.

Many large shipbuilding companies are using great quantities of air line respirators and chemical cartridge respirators with apparent success.

Summary

The methods of protecting welders and other workers against the inhalation of poisonous fumes and gases produced in welding are here listed in the order of their importance.

(1) Local exhaust ventilation.
(2) Air line respirators.
(3) Filter type respirators, including both a mechanical and a chemical filter. (Such respirators are not safe if there is a deficiency of oxygen.)

General ventilation alone, either natural or artificial, does not afford adequate protection even though it reduces the pollution to a considerable extent. Its importance in all places where welding is being done must not be underestimated.

Bibliography

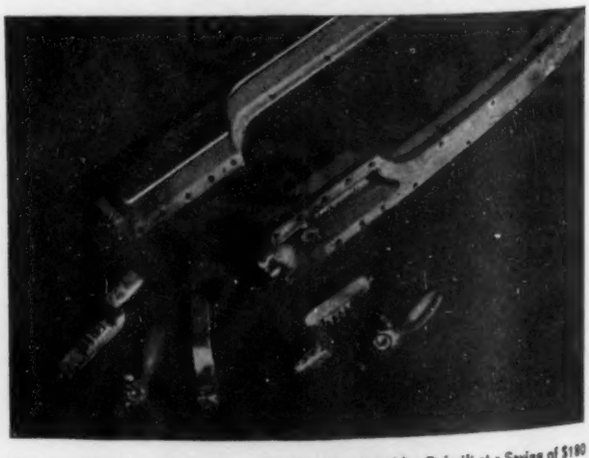
[1] Brown, E. W., "A Study of Lead Poisoning among Oxyacetylene Welders in the Scrapping of Naval Vessels," *Journal of Industrial Hygiene*, **1926**, Vol. 8, pages 113–140.
[2] Titus, A. C., Warren, H., and Drinker, P., "Electric Welding. I. The Respiratory Hazard," *Journal of Industrial Hygiene*, **1935**, Vol. 17, pages 121–128.
[3] Williman, F. L., "Electric Welding. II. An Acute Fatal Pneumonia Following Electric Welding of Galvanized Iron in a Confined Space," *Journal of Industrial Hygiene*, **1935**, Vol. 17, pages 129–132.
[4] Bridge, J. C., "Gassing by Nitrous Fumes," *Factory and Workshop Acts—Industrial Accidents*, April 1934, Vol. 4, page 14. (Printed and published by His Majesty's stationery office, London, England.)
[5] Drinker, P., Warren, H., and Page, R., "Electric Welding. III. Prevention of the Respiratory Hazard," *Journal of Industrial Hygiene*, **1935**, Vol. 17, pages 133–137.

Bronze-Welded Monel Metal

By O. C. JONES†

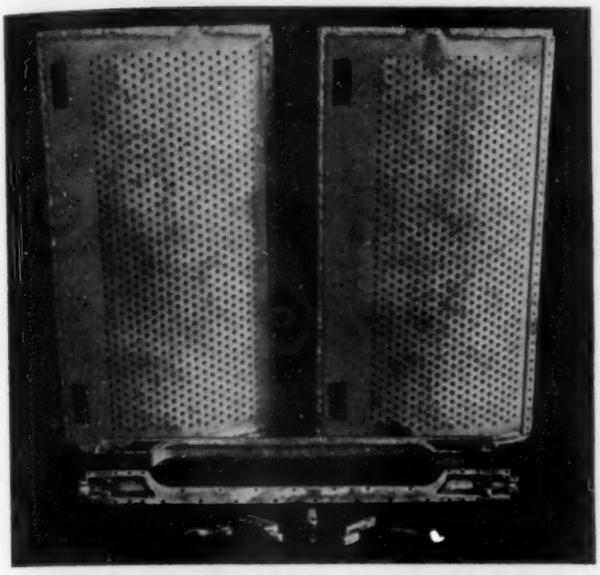
Laundry Machine Parts Rebuilt to Size Save Clothing

MANY laundries are discovering the value of the oxyacetylene process as an indirect means of preventing damage to clothing that has been entrusted to their care. Worn equipment and broken laundry machinery are finding their way to the local contract welding shop more and more regularly for repair and reconditioning, and this is proving to be a mutually profitable arrangement for both the laundry and the welding shop. The laundry business keeps its equipment up to top



Hinges and Locking Mechanism for the Washing Machine Rebuilt at a Saving of $180

† Technical Publicity Department, The Linde Air Products Co.



Washing Machine Cover of Monel Metal Rebuilt to Original Size by Bronze-Welding

efficiency and the welding business obtains more steady work in helping the laundry to do this.

Typical of much of this work is the reconditioning of washing machines. Many of these machines have covers of Monel Metal. Due to vibration of the machine while in operation the edges of these covers wear down almost to razor sharpness. The door hinges and the lock play too much, so that the whole part does not operate as well as it should. This play of the cover, combined with the sharpness of its worn edges, permits the clothes which are being washed to work under the edge of the cover and thus often become cut.

Consequently some method of keeping these particular parts in good shape is of importance to the laundry. A recent trial at a neighboring welding shop convinced a laundry manager that these parts should be continually maintained in the following way.

The edges of the covers, the door hinges and the locking mechanism were all built-up to original size and shape by bronze-welding. The necessary holes where bolts and hinge posts are placed were filled up entirely with bronze and then drilled out to original size.

The edges of the cover were similarly built-up and finished off to original size and shape. The regular bronze-welding technique as used on steel or cast iron was employed for this work on Monel metal with similarly successful results.

Approximately $180 was saved in this way. The laundry is convinced of the excellence and money saving possibilities of maintenance of equipment by the oxy-acetylene process and the welding shop manager looks forward to many more mutually profitable jobs of a similar nature.

The Determination of the Quality of Fusion Welded Joints*

By E. R. FISH†

AS A preface to this subject it should be pointed out that it is necessary to very briefly rehearse the causes that preceded the present conditions.

This is not done in a spirit of antagonistic criticism but rather to give an adequate basis for some constructive suggestions.

There have been innumerable instances of the failure of pressure vessels due to defective welds and it was because of these failures that insurance companies were very hesitant to insure vessels fabricated by welding. This situation, with respect to the dependability of welded joints, made the A. S. M. E. Code Committee also long hesitate to recognize welding as a means of fabricating pressure vessels and that Committee refused to do so until it had been demonstrated that weld metal with proper characteristics could be uniformly produced and that the soundness and fusion of the weld metal to the base metal would be reasonably sure and perfect.

It is not to be wondered that many shops adopted, to a greater or lesser extent, the fabrication of pressure vessels by welding. It is most attractive and enticing both from the point of view of the appearance of the vessel as well as from that of cost and simplicity of production.

In the past fifteen or twenty years a very great number of pressure vessels used for many different purposes have been fabricated by welding and it is principally of these that failures, hereinbefore referred to, have occurred.

It is a matter of common knowledge that up to within six or eight years ago practically all welding was done with bare wire and without giving much, if any, thought to the various factors that contributed to the producton of welds with the desirable characteristics. However, there were some who realized the shortcomings of the method and did much research work to determine how welding should be properly done. But it was not until after the lesson had been learned, that it is necessary to protect the fluid metal from the action of the atmosphere, that the achievement of welds with the desirable properties was attained. The use of special rods in connection with both gas and electric arc methods of welding is now practically universal for the welding of pressure vessels. However, without proper precautions, improper work may very easily result, even though the materials are entirely suitable to the purpose.

It is absolutely necessary that a definite technique or procedure be established by which the welding operator must be guided. After it has been demonstrated, through experimentation and research, that a certain

* Presented at May 22nd Meeting, Chicago Section, AMERICAN WELDING SOCIETY.

† Chief Engineer, Boiler Division, The Hartford Steam Boiler Inspection and Insurance Company.

procedure will result in strong, sound and ductile welds, if carefully followed, that procedure must be adhered to.

Manufacturers generally have learned that because a mechanic claims to be a welder and shows some proficiency in making welds, it is not by any means certain that his work will meet modern standards. In general, these men are desirous of doing good work and take pride in doing so, but not having the opportunity or facilities for making the kinds of investigations necessary to determine whether or not their work is what they hope it to be, they cannot be blamed for any failure to produce good work. It is primarily the function and duty of the manufacturer to determine what materials and technique must be used in making welded joints. On the other hand, it is the function of the welding operator to carry out the prescribed procedure in a skillful manner.

Unfortunately, it is absolutely impossible to determine, by external visual examination, what the character of a joint is. Externally it may look rough and unattractive and yet internally be perfect and have all the desirable physical qualities. And, *vice versa*, an attractive looking weld on the outside may be full of objectionable defects internally.

The fundamental idea back of the Codes, that prescribe what the characteristics of welded joints shall be, is that the requirements are all for the purpose of assuring, as certainly as is practically possible, that the resulting welds shall be reasonably perfect.

It will be recalled that for power boiler construction and for the most dangerous kind of unfired pressure vessel service that there are many requirements provided to determine the character of the welded joint.

Among these provisions is that of making test plates for each object at the same time that the seams of the vessel are welded so that the weld can be properly investigated as to its physical properties. The presumption is that if these test plates are acceptable then the quality of the welded joints in the vessel itself may be accepted as meeting the requirements. In addition, X-raying is required for the purpose of showing, within the limitations of that process, the soundness of the weld metal. Radiographic determination does not in any way disclose the physical qualities of the weld metal. It does show the presence of gas pockets, slag inclusions and lack of fusion, when this latter is so located as to be picked out by the X-rays.

In the case of welded power boilers and U-68 pressure vessels, it is reasonable to assume, when completed and all the Code provisions have been observed, that there is little or no doubt that the joints of the structure can be depended upon, and we need have little or no apprehension about the safety of such structures.

Many U-69 vessels are used for important, and oftentimes quite hazardous service, but the provisions for the fabrication of U-69 vessels are not nearly so searching as for U-68 vessels. No special test plates are required, nor is X-raying prescribed. How may we, then, be reasonably certain that the welded joints of vessels in this category, and in number they are far more numerous than the U-68 vessels, have the proper qualities. It should be demonstrated beyond reasonable doubt that welded vessels of this class have the kind of joints that they are presumed to have.

One requirement of the Code is that all welders engaged in the fabrication of U-69 vessels must demonstrate their ability to produce welds with the prescribed physical characteristics before being permitted to work on vessels which are to bear the Code stamping. It is on the basis of these tests alone that the character of the welds, including the soundness thereof, is judged. They are depended on to indicate the integrity of the welds. The foregoing remarks with respect to U-69 vessels are applicable also to U-70 vessels with the exception that the service of the latter is not likely to be very hazardous and hence there are lighter restrictions. The question now arises as to what extent the dependence just referred to is justified.

Investigations that have been made by insurance companies of welded vessels constructed anywhere from five to twenty years ago have disclosed positively that there were as many questionable welds as good ones produced if indeed there were not many more poor ones. These questionable welds were made not because of any negligence or intention on the part of the fabricator but rather because of ignorance as to their character when completed. All because of the failure to determine beforehand exactly how the work should be done together, with the lack of knowledge, on the part of the operator, on whom dependence was generally placed, of the exact results of his efforts.

The disclosures of these investigations have made the insurance companies feel that, without knowing with relative certainty the character of the welded joints of those vessels that they are asked to insure, they should hesitate to accept the risks.

Furthermore, investigations have been made of vessels that were presumably built in accordance with the present Code requirements and some have been found in which the welds did not have the prescribed characteristics, oftentimes lacking in penetration and having unfused areas.

How, then, may the exact condition of the welded joints, either old or new, be determined in order to be assured that they are in a reasonably safe condition? Apprehension as to their character prompted considerable thought on this point, with the result that several ideas were suggested. Both old and new structures are involved in this scheme.

It must be conceded that only by making an actual examination of the seam by a destructive test can its exact character throughout be determined. Manifestly this is entirely impracticable. However, it is reasonable that a sample, taken from one section of the weld, may be presumed to be fairly representative of the whole weld and it was with this idea in mind that the development of an investigatory method proceeded. The first proposal was to cut an opening across the welded seam about the size and shape of a handhole and then to close this by means of a plate, larger than the hole, placed on the inside and fillet welded for tightness. The idea was that the section of plate removed could be subjected to such tests as would show the soundness of the weld. However, as there was great resistance on the part of owners to doing this, very little progress was made with that particular idea which was soon abandoned.

The next step was to drill a hole, large enough to cover the entire width of the weld, and smooth and etch the walls of the hole so as to bring out any imperfections there might be. This was not very satisfactory because of the difficulty of properly preparing and etching the metal and the difficulty of making a proper examination. However, some few seams were examined in this way with fairly satisfactory results.

The next step was to trepan a small plug or button from across the weld. This involved using a special circular saw. Such tools are readily available. This button, say an inch or an inch and a quarter in diameter, could then be taken to a shop or laboratory, sawed up, the edges properly prepared, and etched.

The etching is done by immersing the specimen in boiling 50–50 hydrochloric acid solution. This brings out, in a most illuminating fashion, the presence of slag

inclusions, gas pockets, and lack of fusion. There is no doubt about the character of the weld at that point.

The preferable method of closing a trepanned hole is by means of a threaded plug. The tapping may be either straight or tapered. In either case tightness can be secured by a light bead of seal welding on the outside. With a straight thread this is absolutely necessary. Different methods of welded in plugs have been suggested but the threaded plan now seems best. By finishing off the outside the location of the plug will not be noticeable.

Literally hundreds of welds have been examined by the trepanning method and a surprisingly large number of seriously defective welds have been found. Indeed, in possibly fifty per cent of the cases it was deemed advisable to replace the vessel with one that was properly constructed.

The great advantage of the trepanned plug is that the one in responsible charge of the vessels can be shown exactly what the condition is. There is no theorizing, guesswork or opinion involved. There is the actual incontrovertible evidence of the weld itself.

In addition to owners, it has needed examinations of this sort to prove to many manufacturers, who sincerely thought their work was above criticism, that they were not doing the kind of welding they thought they were. There have been many instances of this kind.

If it is necessary to have sound plates, free from laminations and other defects, is it not just as important that the weld metal that joins the edges of the plate together should be as sound as the plate itself?

That, practically, this is not possible is recognized by the provisions for joint efficiencies in the Code. It is an admission that 100 per cent perfect welds are not to be expected from a practical point of view, but that there is a point beyond which these defects should not be permitted.

In practically all types of pressure vessels minute changes of shape are continually taking place because of pressure and temperature changes. These changes set up stresses of unknown magnitude and distribution but which are very likely to be highly concentrated at weak points. If there is lack of fusion the surfaces are close together but are not amalgamated. This is in the nature of a very fine crack or parting which makes an ideal condition for a real crack to start through the weld, beginning in the metal where the parting ends. There have been found evidences that such cracking does take place. Also in the process of shrinking and cooling there is a considerable tendency for the weld metal to crack. Such defects as lack of fusion form a point for shrinkage cracks to start. These points of possible future failures should be discovered before the vessel leaves the shop.

A description of the exact process of cutting out these plugs has not been attempted in this paper because there are lantern slides covering all the details which will convey a much better idea than a word picture.

In addition to the use of this method for determining the quality of welded seams in vessels already constructed it might, very logically and appropriately, be made a feature of shop inspection. In other words, after a U-69 or U-70 vessel has been completed in the shop, why should not the final item of inspection be the trepanning out of a plug from each unit of a predetermined number of feet of welded joints?

The adoption of this plan would greatly stimulate both the manufacturer and the welding operator to do only the best of work all the time. Not knowing from what points the plugs would be taken, it would be necessary that all the welding be properly made, if the penalties attached to the discovery of imperfect workmanship, were to be avoided. In my opinion the psychological effect thus set up would be a most important incentive to do good work and would do more to maintain a high standard of workmanship than any other one item.

The construction of complicated fittings by fusion welding, that would not otherwise be possible, as well as the welding of pipe lines of all sizes and for all pressures, is growing rapidly. Much of this work has to be done in the field and in a fixed position that requires special ability on the part of the welding operators to do work in all positions. Furthermore, welding can be done only from one side of the pipe. But it is important that full penetration be obtained throughout the thickness of the pipe wall and without the formation of "icicles" inside the pipe.

Qualification of each welder is of great importance because here again the dependence for the production of acceptably sound welding rests on the skill of the men.

There has been less effort expended in this field, on finding out how to produce good welded pipe joints than in the case of pressure vessels and much imperfect work has been produced. To check the kind of work done many specifications now require that an occasional joint be removed. Such sections are cut up and tested by bending, etching, etc. One such examination will give a good indication of the character of the joints generally but a specimen of each man's work is very necessary.

As there are many stresses of unknown magnitude and distribution, in addition to those due to internal pressure, set up in piping it is necessary that practically perfect welds be produced, and that the work be frequently checked. Knowing that any joint may be removed for testing the men are inspired to do their best. Removing a joint of course necessitates making two joints in replacing the section but that is relatively of little importance when the advantage of knowing what kind of work is being done is considered.

The trepanning method may also be used either alone or in addition to the removal of joints. By combining the methods some examination of every joint is possible.

In conclusion I wish to state that I am not attempting to create the idea that the use of welding for the fabrication of pressure vessels is to be condemned. The intention is to emphasize two points: (1) The shortcomings of much of the work that has been done in the past, the uncertainty of the character of the seams; and (2) the fact that good work can be done, that properly welded pressure vessels are safe and can be depended upon to give long life in service.

The industry has builded on past experience to achieve something that approaches perfect results. It is in this way that all progress is made in every line of endeavor.

Design of Welded Trusses*

By ANDREW VOGEL†

Part II

THE first section of this article discussed design principles and the details of a welded Pratt truss. This section will discuss the Warren truss.

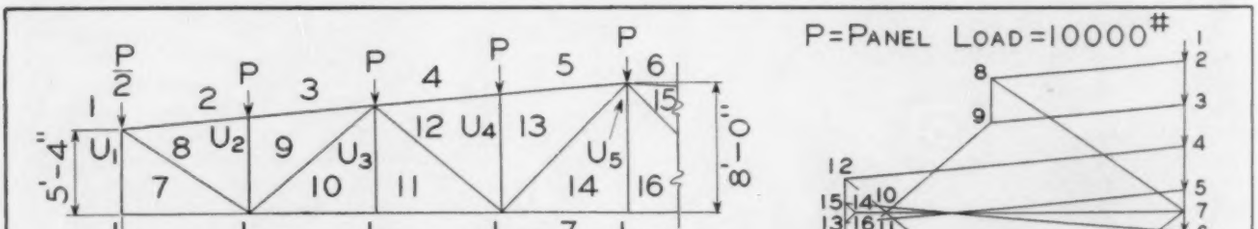
In the design of garages and auditoriums, the Warren truss is very frequently used and the second problem will illustrate the design of a Warren truss with a span of 64 feet, a depth of 5 feet 4 inches at the support and a depth of 8 feet at the center of the truss. The Warren truss has always been popular because it has fewer lower chord joints than the Pratt truss and therefore is sometimes more economical. A recent study comparing some trusses for a building at Bridgeport, Conn., indicated that the Warren truss is not always cheaper than the Pratt truss. In this series of trusses of 80-foot span, consisting of 10 panels of 8 feet each, it was necessary to apply a load of 4000 pounds to each upper panel point, and 6000 pounds to each lower panel point. In view of the fact that verticals were required at all panel lines, it was found cheaper to use a Pratt truss than a Warren truss, as all the diagonals would then be in tension. Bids were obtained on both types of trusses and the Pratt truss selected.

In this problem the usual method of illustrating the design has been followed, that is, vertical loads only are applied and a stress diagram is shown in the upper right corner. In Fig. 8 the essential data for the truss are given, that is, stresses, members selected, unit stresses, and the size, length and position of welds are indicated. This table shows that only angles are used, and that on account of the span and loading of the truss, most of the welds are only $^1/_4$-inch fillet welds.

Figure 9 illustrates two designs of joint U_1. In the upper detail, the outstanding leg of the angle is above the truss line. In the lower detail, the outstanding leg is below the truss line. It will be observed that the only difference in detailing is that in the upper detail the stiffeners are placed directly on the center line of the column, while in the lower detail, the stiffeners are located as near as possible to the center line of the column, but actually about 1 inch to $1^1/_2$ inches to the left of the center line of the column. This does not make any practical difference and therefore one design is just as good as the other.

* Continued from June 1936 issue WELDING JOURNAL. Reprinted with courtesy Industry & Welding.

† General Electric Company.



MEMBER	STRESS	SECTION	AREA SQ. IN.	L/R	STRESS ALLOWED	STRESS ACTUAL	SIZE, LENGTH & POSITION OF WELDS		
U_4-U_5	-82500	$\frac{1}{2}$-16" CB-37#	5.44	60	15000	15200			
L_4-L_5	+80000	$\frac{1}{2}$-14" CB-30#	4.40	—	18000	18200			
U_1-L_2	+56500	2 ∟ 2½"×2"×⅜"	3.10	—	18000	18200	5/16"×4"		5/16"×8"
L_2-U_3	-33000	2 ∟ 3½"×3"×¼"	3.12	113	10530	10600	¼"×2½"		¼"×6"
U_3-L_4	+12500	2 ∟ 2½"×2"×¼"	2.12	—	18000	5900	¼"×1"		¼"×2½"
L_4-U_5	+3750	"	"	—	18000	1770	"	"	"
U_2-L_2	-10000	"	"	92	12243	4720	"	"	"
U_3-L_3	0	"	"	—	—	0	"	"	"
U_4-L_4	-10000	"	"	113	10530	4720	"	"	"
U_5-L_5	0	"	"	—	—	0	"	"	"

Fig. 8

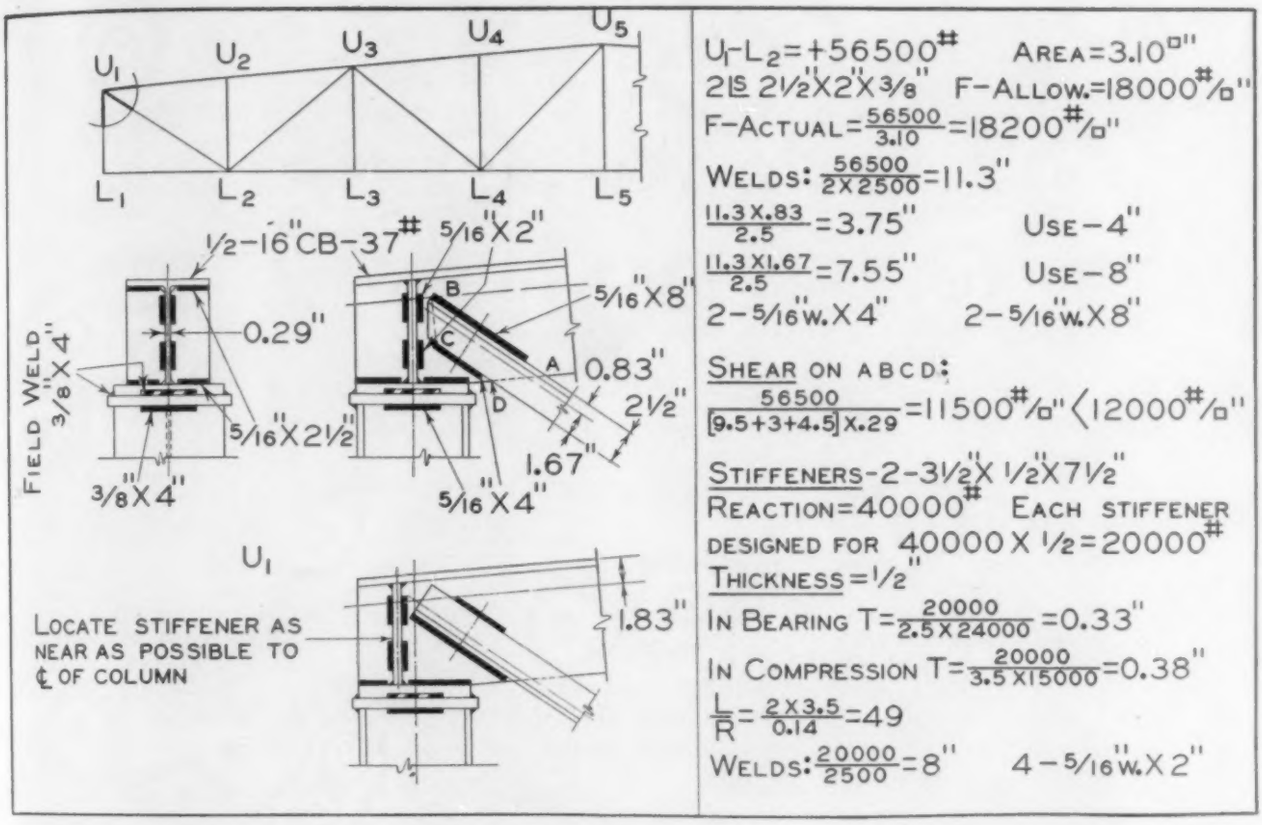


Fig. 9

It will be observed that the upper and lower chords of the truss are halves of I-beam sections. The upper chord is half of a 16-inch CB 37-pound, while the lower chord is half of a 14-inch CB 30-pound. It is economical to use different sizes of chord sections, if an equal number of trusses is called for. The length of the welds is determined in the same manner as given heretofore. On account of the fact that the web of a beam is generally rather thin, it is necessary to calculate the shear around the end of the diagonal, to determine whether or not the web is thick enough to sustain the stresses upon it. The shear on the line *A-B-C-D* is, therefore, calculated on the basis of dividing the stress on the diagonal by the area subjected to shear. The web thickness is only 0.29 inch and the calculation shows that the shearing stress amounts to 11,500 pounds per square inch. Inasmuch as this stress is less than 12,000 pounds per square inch, the web is of sufficient thickness.

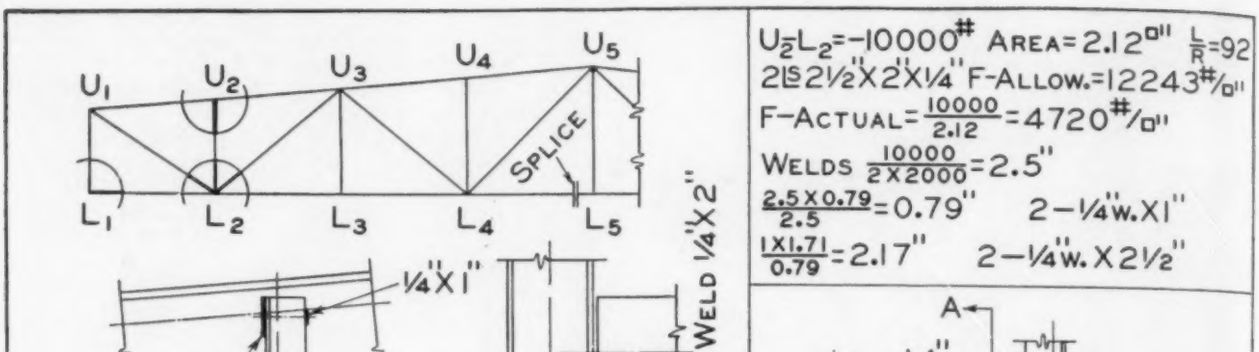
The size of stiffeners is determined from the reaction. Each stiffener is assumed to carry one-half the reaction, that is, 20,000 pounds, and its area is determined from the fact that the maximum stress in bearing should not exceed 24,000 pounds per square inch. The capacity of the stiffeners as a column was analyzed and found to be adequate. The amount of welding is determined by the fact that 20,000 pounds would be applied to the end of each stiffener, and, if $^5/_{16}$-inch welds are used, with a capacity of 2500 pounds per linear inch, 8 inches of $^5/_{16}$-inch fillet welds are required to join the stiffener to the web of the upper chord. Four $^5/_{16}$-inch welds, 2 inches long, were therefore indicated on the drawing.

Figure 10 shows details of joints L_1, U_2, L_2 and splice near joint L_5. Joint L_1 is simply a field connection holding the member L_1, L_2 to the column, and under vertical loading carries no stress. As pointed out before in the design of the Pratt truss, this member may be subjected to stress from wind loads or horizontal loads produced by other forces.

For joints U_2 and L_2, the only calculation shown is that for the vertical strut. The calculations for the other angles are made in a similar manner. On all compression struts, a $^1/_4$-inch by $1^1/_2$-inch bar is shown placed between the angles and then welded on the edges in order to connect the angles together. The same result could be accomplished by making the bar shorter than shown in the illustration and welding between the angles. Inasmuch as it is sometimes difficult to weld between angles, possibly the method shown on the drawing would be considered the better method.

The splice detailed is unusual in that angles are used in such manner that it is necessary to machine the outer corner of the angle splice bar. This splice has been used on only one series of trusses to the writer's knowledge, but it is worth your consideration as a certain principle of design is involved. The center of gravity of the angle was located and then the diagonal distances from the edges of the angle to the center of gravity of the angle determined as shown on View *A-A*. The distances from the center of gravity of the angle to the edges of the angle were about equal and therefore, the length of the welds was made the same on both edges of the angles. The calculation is relatively simple and clear, but the method of making the splice is particularly called to your attention.

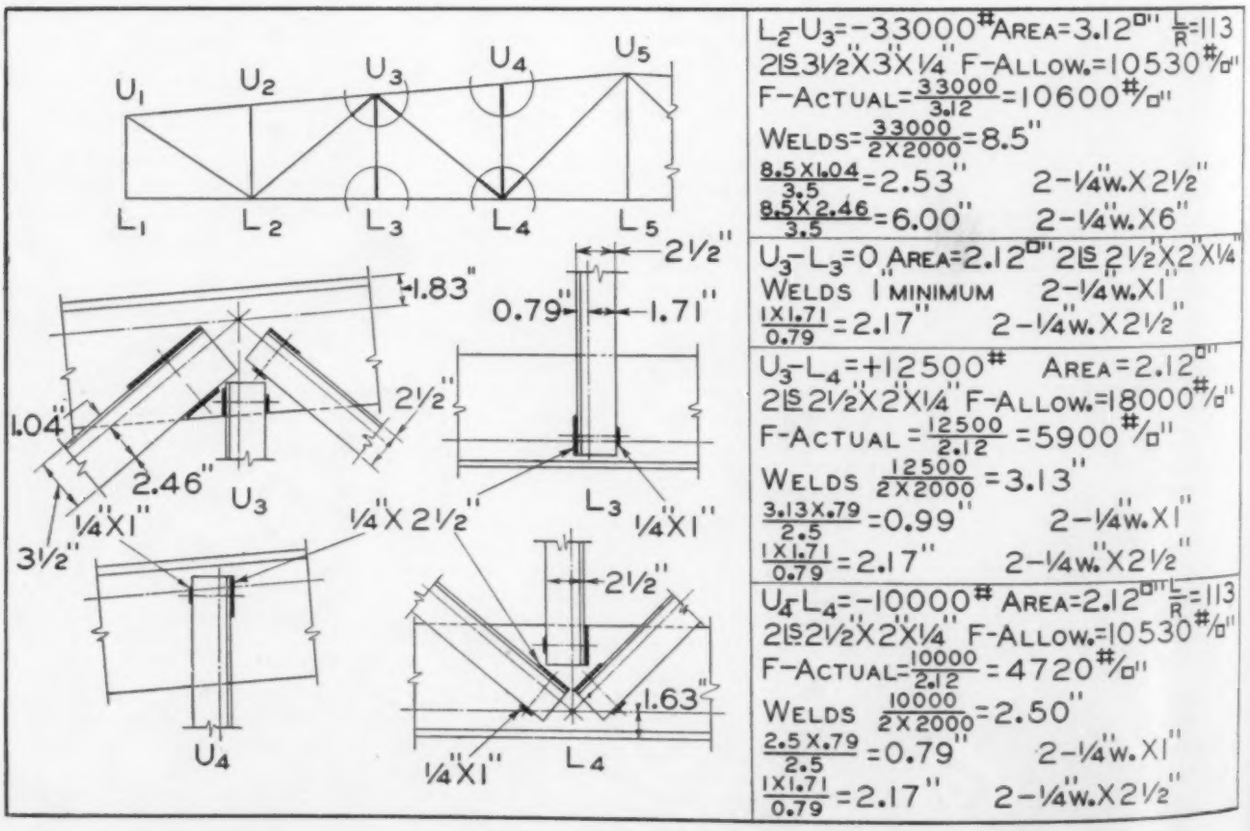
Figure 11 illustrates details of Joints U_3, U_4, L_3 and L_4. The only new principle involved in this figure is that of the use of minimum size welds. Experience has shown that the smallest weld which is practicable on a structure of this type is the $^1/_4$-inch fillet weld, 1 inch long. If the usual practice is followed of making the capacity of the weld on one edge of the angle times the distance to the center of gravity of the angle, equal to the



U_2-L_2=-10000# AREA=2.12□" $\frac{L}{R}$=92
2LS 2 1/2"X2"X1/4" F-ALLOW.=12243#/□"
F-ACTUAL=$\frac{10000}{2.12}$=4720#/□"
WELDS $\frac{10000}{2X2000}$=2.5"
$\frac{2.5X0.79}{2.5}$=0.79" 2-1/4"w.X1"
$\frac{1X1.71}{0.79}$=2.17" 2-1/4"w.X2 1/2"

SPLICE-2LS 3 1/2"X3"X1/2"X22"
AREA OF 1/2-14CB-30#=4.40□"
AREA OF SPLICE=6.00□"
WELDS $\frac{4.40X18200}{2000}$=40.0"
4-1/4"w.X10"
LENGTH OF SPLICE=[2X10"]+2"=22"

Fig. 10



L_2-U_3=-33000#AREA=3.12□" $\frac{L}{R}$=113
2LS 3 1/2"X3"X1/4" F-ALLOW.=10530#/□"
F-ACTUAL=$\frac{33000}{3.12}$=10600#/□"
WELDS=$\frac{33000}{2X2000}$=8.5"
$\frac{8.5X1.04}{3.5}$=2.53" 2-1/4"w.X2 1/2"
$\frac{8.5X2.46}{3.5}$=6.00" 2-1/4"w.X6"

U_3-L_3=0 AREA=2.12□" 2LS 2 1/2"X2"X1/4"
WELDS 1" MINIMUM 2-1/4"w.X1"
$\frac{1X1.71}{0.79}$=2.17" 2-1/4"w.X2 1/2"

U_3-L_4=+12500# AREA=2.12□"
2LS 2 1/2"X2"X1/4" F-ALLOW.=18000#/□"
F-ACTUAL=$\frac{12500}{2.12}$=5900#/□"
WELDS $\frac{12500}{2X2000}$=3.13"
$\frac{3.13X.79}{2.5}$=0.99" 2-1/4"w.X1"
$\frac{1X1.71}{0.79}$=2.17" 2-1/4"w.X2 1/2"

U_4-L_4=-10000# AREA=2.12□" $\frac{L}{R}$=113
2LS 2 1/2"X2"X1/4" F-ALLOW.=10530#/□"
F-ACTUAL=$\frac{10000}{2.12}$=4720#/□"
WELDS $\frac{10000}{2X2000}$=2.50"
$\frac{2.5X.79}{2.5}$=0.79" 2-1/4"w.X1"
$\frac{1X1.71}{0.79}$=2.17" 2-1/4"w.X2 1/2"

Fig. 11

capacity of the weld on the other edge of the angle times its distance to the center of gravity of the angle, it will be necessary to use about 2 to $2^1/_2$ inches of $^1/_4$-inch fillet weld at the heel of the angle, when a $^1/_4$-inch by 1-inch fillet weld is used at the toe of the angle.

An alternative method has also been developed. If the angle is $^1/_4$ inch thick, a $^1/_8$-inch by 1-inch fillet weld may be placed at the toe of the angle, and a $^3/_8$-inch fillet weld of the required length to balance the welding, is placed at the heel of the angle. As a general rule, the weld at the heel of the angle usually works out to be a $^3/_8$-inch fillet weld about $1^1/_2$ inches long, and this is the minimum length usually used for $^3/_8$-inch fillet welds. In this manner, both welds are the economical sizes and lengths of welds which can be used on minimum size joints. It is interesting to observe that in a truss of this type, it is difficult to use as little welding as the design requires, and that minimum size welds are generally the rule on the web members approaching the center of the span of the truss.

Figure 12 illustrates joint U_5. This joint is at the apex of the truss and it involves certain splicing problems in addition to the application of web members. If the upper chord of the truss is to be fabricated as economically as possible, it should be a half beam of full length of the truss. At the lower left corner is illustrated a method of forming the apex of the upper chord. The chord is cut with a gas torch, first gas cutting a hole through the web near the flange and then cutting a wedge-shaped piece from the web. The chord member is then bent so that the wedge-shaped space is eliminated. The joint is then butt-welded as shown in the lower center illustration. In the lower right corner of the figure is shown an angle applied across the butt weld to complete the splice. When this detail was prepared, full reliance had not as yet been placed on butt welding in building construction. Since this detail was drawn, it has not been uncommon to butt-weld a compression splice and omit any angle or bar across the splice.

If an angle is used to complete the splice of the upper chord, the location of this angle is so arranged that the center of gravity of the uncut flange and the angle coincides with the center of gravity of the member. It will be observed that a $^3/_8$-inch by 7-inch fillet weld is placed at the heel of the angle and a $^1/_4$-inch by 7-inch fillet weld at the toe of the angle. In the illustration at the upper right corner, a 3-inch by $^3/_4$-inch bar is used to complete the splice of the upper chord and a $6^1/_4$-inch by $^5/_8$-inch plate is placed on top of the flange. This method of splicing is used only when the chord is cut in two, that is, the chord is not bent as previously described. Inasmuch as this method is not often used, and the method shown at the lower part of the figure is the one most generally used, it will not be discussed in detail.

As newer methods and better electrodes come into use, it is found that direct butt welding, without the aid of any splice bars, is entirely satisfactory for compression members. On tension members, however, it is still the practice to use splice bars, and depending on fillet welds in shear to transmit the stress from one member to another.

Recently, a group of 11 Pratt trusses of 80-foot span with a depth of 9 feet 4 inches and consisting of ten panels of 8 feet each, were fabricated and erected for a building in Bridgeport, Conn. The upper chord consists of half of an 18-inch CB 50-pound, which is butt-welded at the splicing point, near the center of its span, as it was necessary to splice the truss for erection reasons. In this case, the butt welding is amplified by the use of a bar on the top flange, more for alignment and erection purposes than to add to the strength of the joint. The lower

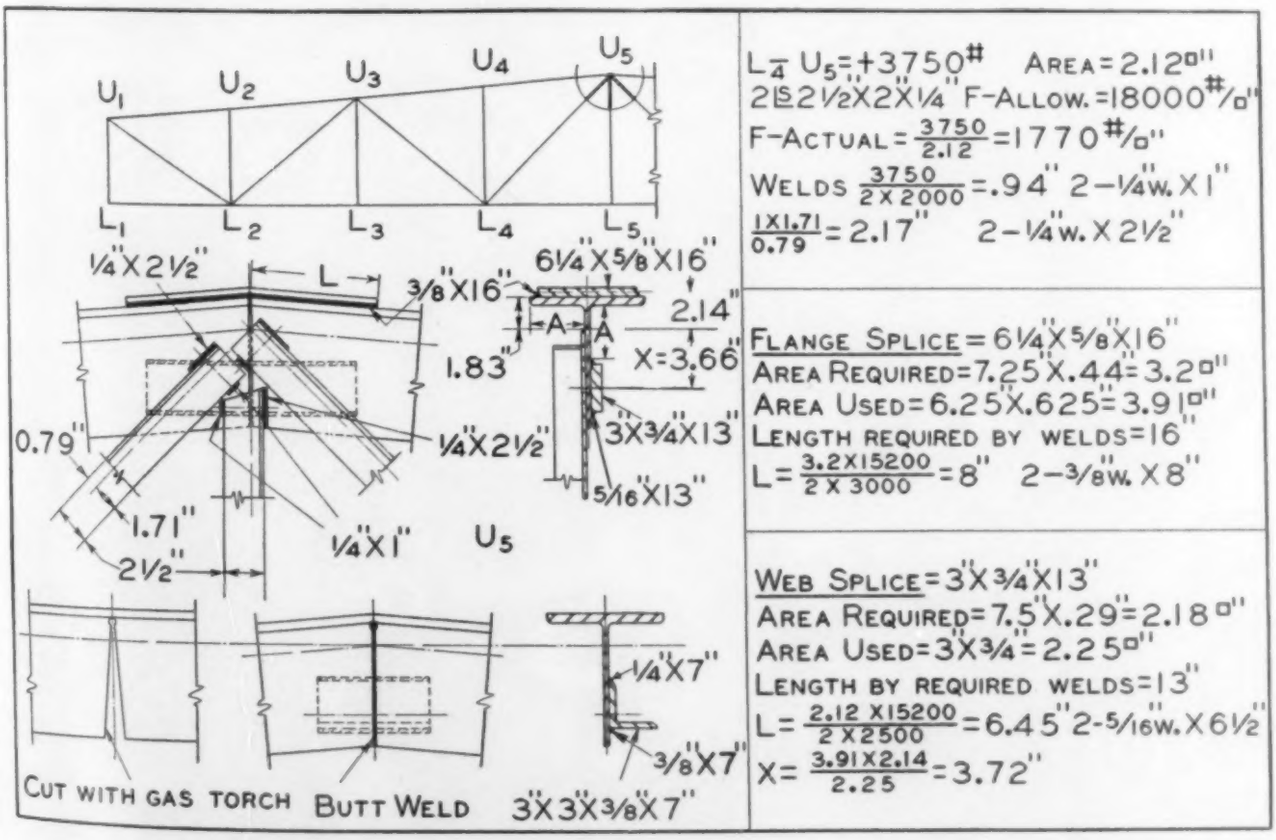


Fig. 12

chord consists of half of an 18-inch CB 50-pound, but this is spliced both on the flange and on the web with splice bars, in all cases depending on fillet welds in longitudinal shear to transmit the stress. The splice bar method was found to be the more economical method for the tension chord when the stress in the butt-welded joint is limited to 13,000 pounds per square inch.

These Pratt trusses have diagonals in the end panel which are in compression, thus making the joint of the lower chord to the column the main joint carrying the reaction of the truss. The columns are continuous above the trusses, and therefore, the trusses land on heavy brackets welded to the columns. Incidentally, the detail of this lower chord to column connection consists of a piece of 18-inch CB 50-pound beam, with enough of the upper flange burned away by a gas torch to permit the diagonal angles to come down onto the web. The result is a very satisfactory and neat connection.

The design of welded structures is progressing rapidly. Although most of the difficult problems have been solved, there is still room for improvement in designing details which produce the desired results at minimum cost. In view of the fact that there are such interesting economies to be obtained by the use of welded trusses, it is surprising that they are not more generally used. It is quite probable that the reason is that designers throughout the country are not fully familiar with designing methods, or the advantages to be obtained. Where designers are familiar with the design of welded structures, it is not uncommon to find trusses of welded construction and the other parts of the structure of other materials or types of construction.

The text and figures of this article describe and illustrate some of the advantages of the many trusses which have been fabricated by welding during the past few years. The absence of gusset plates and other connection details, combined with the omission of punched holes which must be accurately dimensioned, not only results in less cost for drafting, but also in simplification of the work in the shop. Only two types of trusses have been discussed. The field of structural welding covers buildings, bridges and even the frames of machines, and in all these fields metallic arc welding is becoming an indispensable tool in engineering progress.

Portable Welding Shop

By J. C. CARTER†

IN A farming territory transportation difficulties often make it practically impossible to carry broken or worn equipment to a welding shop for repair. A very clever solution for this problem was found by one ingenious welding operator. He mounted on an automobile trailer a small acetylene generator and the necessary oxyacetylene equipment. Grinding wheels, jigs and fixtures, a vise and other miscellaneous tools completed his portable welding shop.

On a visit to a local auction of farm machinery, this operator found fifty broken parts in forty machines being put up for sale. One was a new corn harvester worth $350, which had three cast-iron gears broken. He suggested to a farmer who was anxious to buy it that he would weld the gears. The job was completed with very satisfactory and gratifying results.

Other auctions and fairs produced similar jobs. Thus the idea of the portable welding shop was conceived. He felt that there were many people who would like to take advantage of an opportunity to have things repaired by means of the oxyacetylene process, but that they were too far away from any center where a contract shop existed. Thereupon he decided that perhaps if he took his welding shop to them, he would get the business.

The result of this reasoning was the construction of the portable trailer shop. It is the custom of this operator to go to auctions, garages, golf courses, blacksmith shops, large farms, county fairs and other places where welding work may be found. The repair work is carried on in the presence of the owner, and the advantages and savings are pointed out.

Among other things, he has found that there is a great deal of hard-facing work waiting to be done. Wherever he goes he is requested to hard-face tools, agricultural implements and other wearing parts, as well as the necessary welding repairs.

The results of this enterprising effort have been very gratifying. It has been possible for him to build up a very profitable business for himself and also has enabled him to make very large savings for his customers. The experience of this operator creates a suggestion that many welding shop owners should find extremely interesting, particularly if they are looking for ways and means of extending their operating territory.

† Technical Publicity Department, The Linde Air Products Company.

Mounting the Necessary Oxyacetylene Welding Equipment on an Automobile Trailer Enables the Welding Operator to Reduce Transportation Difficulties by Going Out to the Work That Has to Be Done

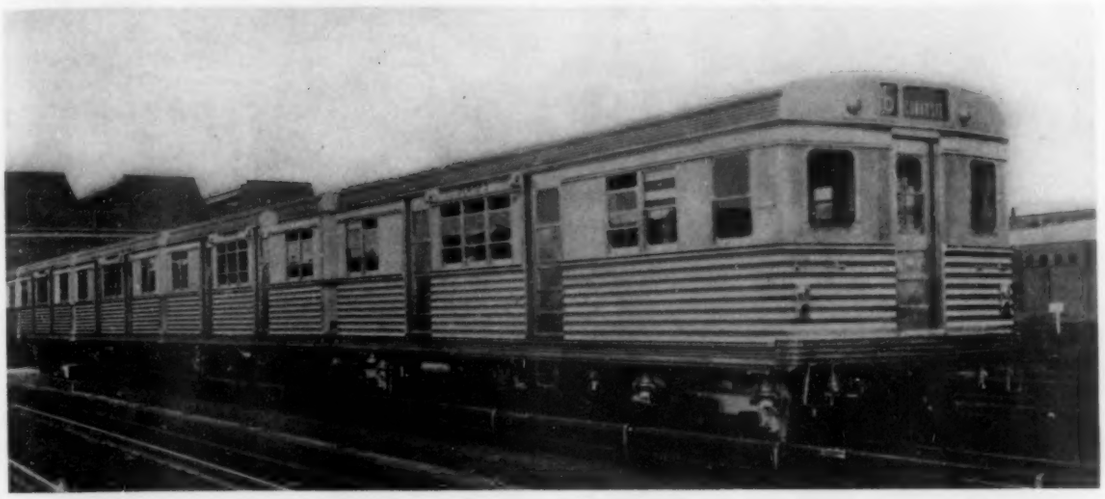


Fig. 1—Multi-Section Car of "Shot-Weld" Stainless Steel Construction Built by Edward G. Budd Manufacturing Company, Philadelphia, for B. M. T. Lines, New York. It Is Equipped with Welded Steel Truck Frames, Bolsters and Spring Planks

Welded Steel Truck Frames for B. M. T. Lines Multi-Section Cars

By G. D. SPACKMAN†

IN 1934, two experimental five-section articulated subway-elevated cars were built for the B. M. T. Lines, New York, N. Y. They were designed to speed local service up to almost express schedule by quicker acceleration and deceleration, without making necessary any reinforcement of the existing elevated structure. One of these multi-section cars, shown in Fig. 1, was constructed by the Edward G. Budd Manufacturing Company, Philadelphia, Pa., in "Shot-Weld" stainless steel construction, and weighed substantially less than comparable cars of conventional design.

As a means of contributing to the weight reduction of the multi-section car, welded steel truck frames, bolsters and spring planks, fabricated by Lukenweld, Inc., division of Lukens Steel Company, Coatesville, Pa., were used on the Budd-built unit placed in service in July 1934.

Figure 2 illustrates one of the welded steel truck frames, fabricated from Cromansil steel. It was made up of 78 separate pieces of varying sizes and shapes, integrated by welding. The flange metal was $^{9}/_{16}$ inch in thickness, and webs in general were $^{5}/_{16}$-inch plate. The method of carrying the journal reaction into the frame proper, and the method of producing the journal box guides from a single formed plate are clearly shown in the illustration. This frame, one of six produced for the Budd-built train, weighed approximately 1500 pounds before machining.

Figure 3 shows one of the welded steel bolsters, also fabricated entirely from Cromansil steel in the weldery of Lukenweld, Inc. This structure weighed 340 lb. before machining.

The Budd-built multi-section car was placed in service in July of 1934. A close-up view, showing the articulation of the units and one of the welded steel trucks, is shown in Fig. 4.

† President, Lukenweld, Inc.

As a result of the experience gained in the operation of the two experimental trains, the B. M. T. Lines recently ordered twenty-five five-car articulated units. Ten were purchased from the St. Louis Car Company, St. Louis, Mo.

In considering the type of truck frame, bolster and spring plank for these units, a number of designs were studied. One design, in pressed steel and castings integrated by riveting, showed fairly favorable weight, but was estimated to be 4000 pounds heavier per train than the welded design. This 4000-pound saving possible through the welded design—comprising two-thirds of the total weight variation permitted in the building of the units—was obviously highly desirable not only from the standpoint of power saving in train operation, reduced wear and maintenance on wheels, track and other elements, but also because it would eliminate the necessity

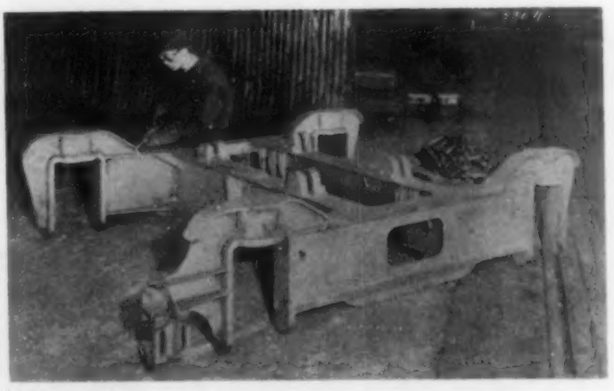


Fig. 2—Welded Steel Truck Frame, Fabricated by Lukenweld, Inc., from Cromansil Steel, Which Weighed about 1500 Lb. before Machining, and Used on the Budd-Built Multi-Section Car for B. M. T. Lines

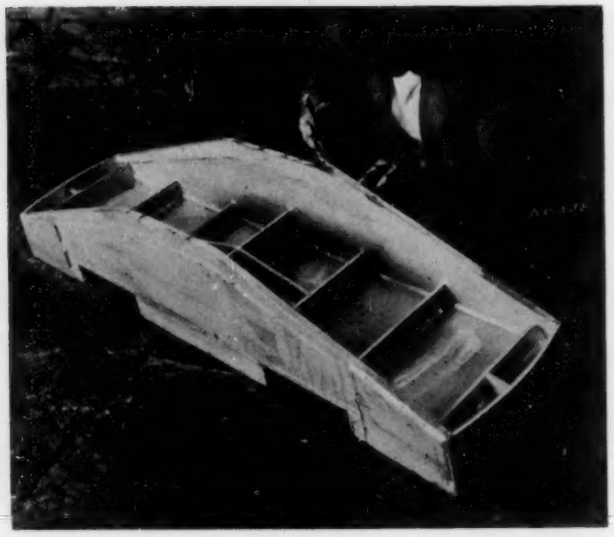


Fig. 3—Welded Steel Bolster from Cromansil Steel, Weighing 340 Lb. before Machining, Used on the Budd-Built Multi-Section Car for B. M. T. Lines

of making other reductions in the weight of the car structure which might reduce its collision strength.

The B. M. T. Lines accepted welded steel construction for the truck frames, bolsters and spring planks. The welded truck frames are composed of pressed plate members of Cromansil Steel, generally 1/4 inch thick, and electric furnace castings of Cromansil analysis.

Due to the greater quantity of duplicate units involved compared to the six frames, bolsters and spring planks required for the original Budd-built experimental train, an entirely different design view-point was necessary from the production angle. Introduction of formed plate sections became economically attractive. It was also considered advisible to apply the swing link bearings (which had been built into the original six frames) at the final assembly of the truck. Small pads, machined to take the bearing blocks welded on at the final assembly, welded to the top flange of the transom members, eliminated the drilling and boring operation which would have been relatively costly if done on the completed frames.

Consideration of contours at the intersection of formed sections, plus the small details incidental to the support of brake rigging at these points, dictated use of Cromansil steel castings in the corners where the transom intersects the side members.

In the new design of welded truck, an important change was the introduction of single shoe brakes. The two brake cylinders were located at the extreme ends of the truck, diagonally opposite. The small details, the box section necessary to resist lateral stresses set up by cylinder reactions, and the quantities involved, combined to indicate the desirability of cast steel pedestals, which were made in Cromansil analysis. These castings cease, and are butt-welded to the 1/4-inch formed side member sections, at points immediately behind the inner journal box guides. Due to their complicated nature, the thinnest metal section that could be obtained, consonant with sound castings, was 3/8 inch.

At a center plate loading of 34,000 pounds, the design stress in these trucks is approximately 24,000 pounds per square inch, which is about 40 per cent of the endurance limit of the base material, as shown by rotating beam tests. The experimental truck frame was found adequate for this design stress and as an additional precaution, all fillets were carefully ground and considerable effort was expended in eliminating abrupt changes in contour.

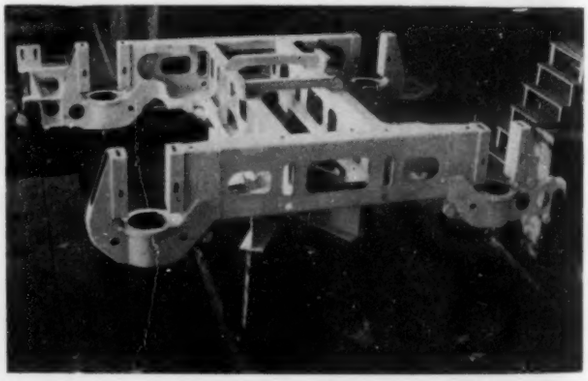


Fig. 5—Top View of Test Set-Up Used in Destruction Test of Welded Steel Truck Frame

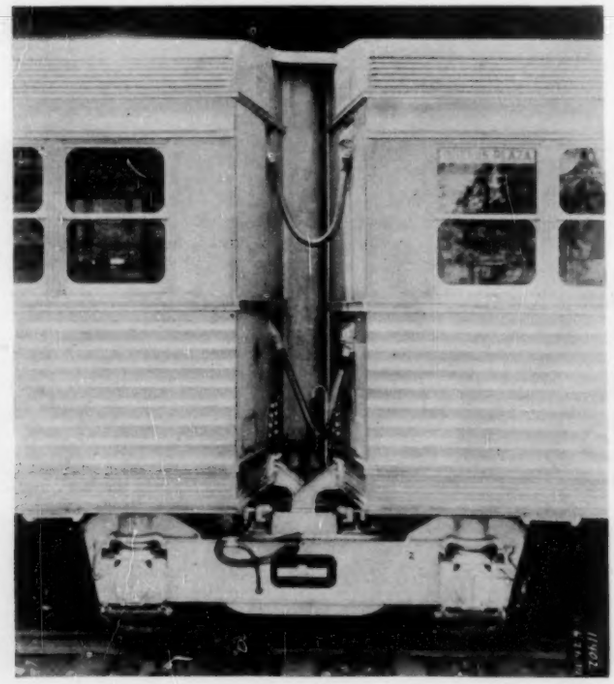


Fig. 4—Close-Up View, Showing the Articulation of the Units—and a Welded Steel Truck—on the Budd-Built Multi-Section Car for B. M. T. Lines

Cromansil steel, in a 0.17 carbon grade, shows a yield strength of about 62,000 pounds per square inch, an ultimate strength of 95,000 pounds per square inch and an elongation in 8 inches of 26 per cent. The carbon content is purposely limited to 0.17 because of the damage to the higher carbon steels through the welding heat, and while these trucks are thoroughly heat-treated after welding, it is possible that at some future date minor repairs or additions might be necessary on the trucks and the low carbon content of the steel assures completion of any such repairs with minimum hazard.

While the design stress of 24,000 pounds per square inch may seem to be high, it is the sum of the stresses due to all possible loads that might occur at the same time. Several units of welded railroad equipment have given successful service over a period of years working at this stress. Notable examples are the welded steel underframes in service on the first Burlington Railroad three car "Zephyr" and other high speed streamlined trains, in which the calculated maximum stress is 26,000 pounds per square inch.

Fig. 6

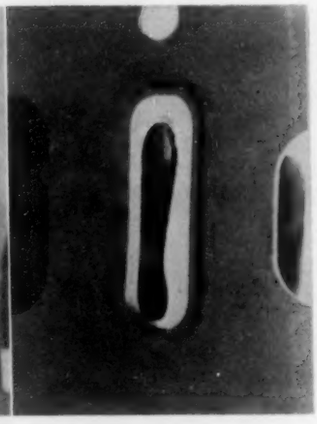


Fig. 7

Fig. 6—Close-Up View of Edge of Web Which Buckled in Destruction Test of Welded Steel Truck Frame. The Crippling Appears to Be a Pure Column Failure

Fig. 7—Another View of the Crippled Web in the Destruction Test of the Welded Steel Truck Frame

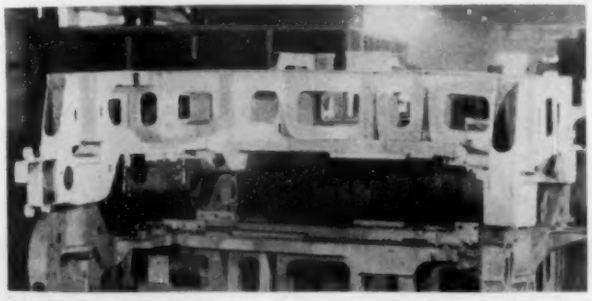


Fig. 8—View of Tested Welded Steel Truck Frame, Showing General Distortion on Right Side of the Frame, Which Occurred at Test Load of 99 Tons

In Cromansil steel and at the working stress of 24,000 pounds per square inch, the total weight of two pilot trucks, four articulated trucks, six bolsters and six spring planks is 10,710 pounds per 127,000 pound train, which gives an average weight per truck of 1785 pounds including spring plank and bolster.

Absolute minimum weight was essential in the trucks of these trains, due to the fact that they are to be placed in local service in which expressed schedule time must be maintained, and the accelerations and decelerations of local service are very frequent. Therefore the inertia of the train must be as low as is consistent with long service life and safety.

In view of the fact that the webs of the trucks were rather completely cut up with holes required for accessibility to the brake shoes and other working parts, it was believed that a destruction test was the only method by which some idea could be obtained of the over-all strength of the truck frame itself.

Figure 5 shows the top view of the test set-up in which the main load is applied through the hydraulic jack seen at the bottom of the picture, through an X-shaped member to the swing link hanger pads, and the reaction was taken through four tie rods, the nuts of which seated on the insides of the spring pockets.

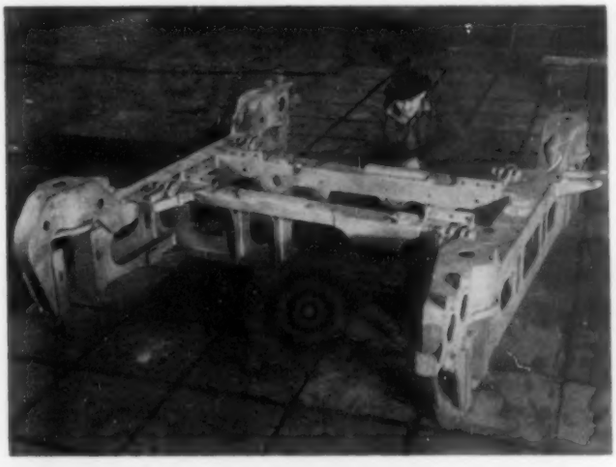


Fig. 9—General View of Completed Welded Truck Frame for a Multi-Section Car Being Built by St. Louis Car Company, St. Louis, Mo., for B. M. T. Lines, New York. The Welded Truck Frame Weighs 1435 Lb.

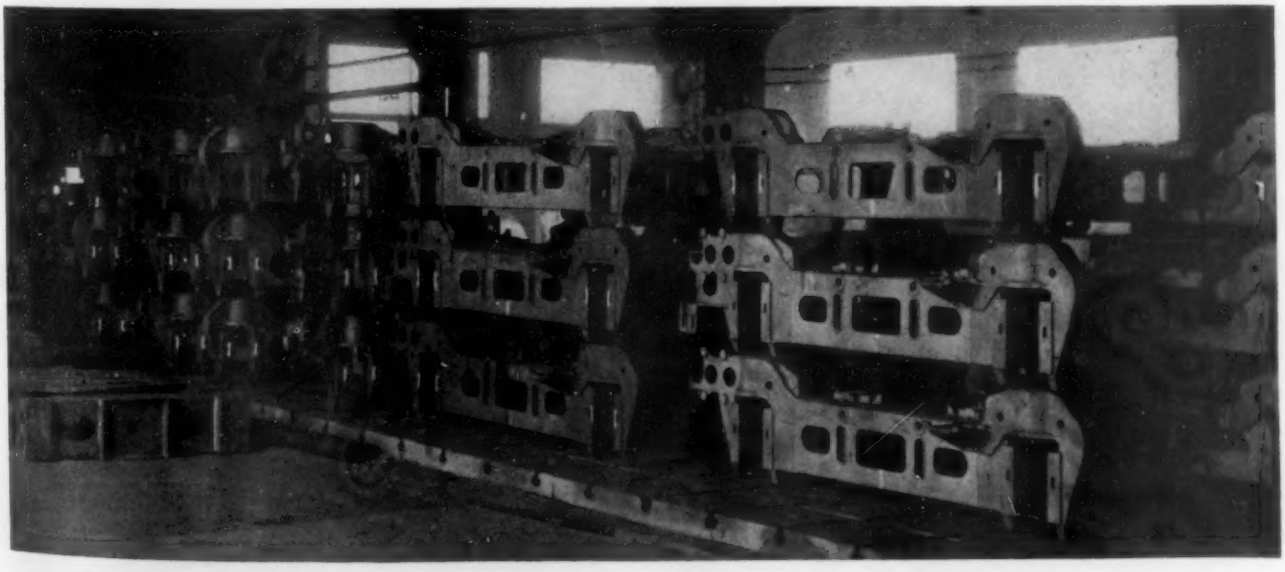


Fig. 10—Group of Welded Steel Truck Frames, Weighing 1435 Lb. Each as Shipped from Lukenweld, Inc., to St. Louis Car Company, St. Louis, Mo., for Use in Building Multi-Section Cars for B. M. T. Lines, New York

Fig. 11—Group of Welded Steel Bolsters, Each Weighing 270 Lb. for Use in the Construction of Multi-Section Cars for B. M. T. Lines, New York

It will be noted that the vertical oval holes in the side member are cut adjacent to the intersection of the transom. These holes are required for the passage of conduit and air pipe connections through the side members. It was believed that this region was beyond analysis, and it was also thought that these holes should be reinforced. For purposes of the destruction test, the reinforcing bands deemed necessary around the holes were not welded.

After the truck frame was thoroughly lime-washed, the load was applied in increments of five tons up to 85 tons, and this load was released to determine if any permanent set had occurred. No permanent set was discernible and the load was then increased to 99 tons, at which point failure occurred by crippling of the thin, unsupported transom web at the point where the transom intersects the side member. Figure 6 is a close-up photograph taken of the edge of the buckled web. It appears to be a column failure.

No flaking of the lime wash occurred at any point, and the tack welds around the reinforcing bands in the side member broke, which showed the need for reinforcement at that point. The only suspicion of flaking of the lime wash occurred around the $1^1/_2$-inch hole just below the reinforced openings. None of the main welds showed any distress whatever.

Figure 7 is another view of the crippled web, taken through the oval holes in the side member. After this transom web crippled and unloaded itself, a general distortion occurred on that side of the frame, as is shown in Fig. 8. The destroyed truck has been placed upside down on another truck, and the distortion of the right-hand side can be clearly seen.

It was believed that the ratio of the crippling load to the working load was sufficiently high to warrant use of the design, without changes.

Design of Welded Steel Structure*

By ROBT. E. KINKEAD†

ANY designer of machinery and equipment can design for welded steel construction if he has a list of standard welds and information on the kind and amount of loading each standard weld will carry.

The design problems of saving money with welded steel designs are problems of cutting and forming available steel rather than problems of welding. There are certainly not less than 400 machinery and equipment designers in Pittsburgh and Youngstown district who design in welded steel construction with the same freedom that they design in castings.

Many of the heated arguments between advocates of steel castings and welded steel have been settled in the time honored way. The proponents of welded steel are using more steel castings and the steel casting enthusiast finds himself using more welded steel. Human nature seems to work that way.

It was not so long ago that we all hated and feared Lenin and all his works, yet we find ourselves doing things with our government that are little short of communistic. On the other hand the Soviets have adopted the piece-work and incentive system which they once cited as our worst industrial fault.

The fact that the world is changing rapidly is perhaps some justification for what I have to say.

Ideas have been born as a result of welding experience which are likely to produce far reaching changes in the design of all metal structures. It would be an unwarranted assumption on my part to try to tell you what is going on in the world of design of metal structures today. There are too many men who know more about that than I do.

The best I can do is to suggest to you what I believe is likely to happen in the field of design from my point of view. That point of view is the result of experience in a highly specialized field of technical knowledge, *Welding*.

The primary conception of welding is as a method of repairing something that has been badly worn or broken.

A second conception is that of using welding as a means of manufacturing an assembly of metal parts into some useful product.

A third and possibly the latest conception of welding is that of building a continuous metal structure in which the metal at any location is of such physical properties as to just meet the service requirement at that point.

This idea seems likely to do more things to our traditional methods of making and using steel than anything that has happened in metal working in a long time.

For thirty years, the steel mills have been trying to make steel uniform in chemical analysis and physical properties. The idea of which I speak is likely to make the steel mills spend the next thirty years trying to keep from making steel uniform.

Let me illustrate the point by the case of the bath tubs in this hotel. They are made of porcelain—baked mud, if you please. They weigh 800 to 1000 pounds and are relatively expensive. The steel structure of the building had to be made heavy enough to support some 1500 of them. The same general proportions hold for toilets, lavatories and radiators, marble floors, etc. Now the main reason why these fixtures are made of materials other than steel is that the steel maker has not been able to get it out of his head that steel must be made uniform. Such fixtures and apparatus made of one of the stainless steels would cost too much. But the new idea of using

*Presented at joint meeting Pittsburgh Section, A. W. S., and Mechanical Section, Engineers' Society of Western Pennsylvania and A. S. M. E. Pittsburgh Section.

†Consulting Engineer.

ordinary steel with a thin surface of stainless steel on the outside at a total overall cost of five or six cents a pound changes the picture entirely. The old conception of steel as a homogeneous product is giving way to the new idea of steel as a composite material of construction.

But the conception is not limited to bright and shiney corrosion resistance surfaces—far from it.

Not long ago the rail mills had the experience of having their customers, the railroads, send engineers into the mills to harden rail ends before the rails go into service. The ends batter and wear first. If the whole rail were hard enough to give satisfactory service at the ends, the rail would be too brittle for safety, thus, until a year or so ago rails were uniform steel products. They are now becoming composite products with different physical properties at different locations.

Throughout all of our machine designs from aircraft to lumbering setam locomotives we have queer lumps of reinforcement to take care of stress concentrations because our minds run along the traditional lines that metal must be uniform in physical properties and that the way to get more strength is to make it thicker and heavier. Presently we shall be welding in high tensile inserts where they will do the most good.

But in the design of pipe we reach the heights of absurdity in carrying out the tradition of uniformity of steel. No one has ever heard of a pipe used for a conduit to transfer liquids or gases which had the same necessities to meet on the inside as on the outside. Yet the designer is forced to make some kind of a compromise and use a metal that is uniform inside and out. It does not do the steel industry any particular good to have engineers choose cast-iron pipe in preference to steel pipe in the beilef that it is the best compromise. It is quite likely that steel pipe will presently be offered for sale at competitive prices which is different inside and outside.

Throughout all of the living things of nature, nothing is uniform. It has taken us a long time to learn it but all we can know about the design of anything we have to learn from Nature. She has been working for untold millions of years by trial and error. There is bark on a tree and hard wood around a knot hole because only such conditions have permitted tree life to survive. And nature found it out before a mathematician ever sharpened a lead pencil to figure it out.

If we have insisted on making and using steel structures of uniform metal it is because we have been too dumb to study the experience and ways of the one great Teacher of us all, *NATURE*.

There are sound reasons why steel should not be uniform in chemical analysis or physical properties. Those reasons lie close to the fundamental principle of all design. If I may presume to state the first principle of design of all metal structures, it is that the structure shall just meet all of the service requirements for the period of its normal life and that the cost shall be within economic boundaries. This principle of design is not a dull academic pronouncement—it is as alive and vital as life itself.

Meeting service requirements means that the structure must be strong and safe, that it must behave satisfactorily under all service conditions and that it must be pleasing to the human beings that use it. Good design implies good appearance—it is not good design unless it has pleasing appearance. Good appearance is a utility function and is as essential as long life.

Young designers often sneer at labor and effort to make a machine or structure have pleasing appearance. Good line and form is something their handbooks do not mention. But nature knows the utility value of good appearance. The Easter flowers we have been seeing in such a lovely profusion of colors were not beautiful by accident, but by Nature's design. The slender and graceful lily, demure in old ivory and cream with a splash of yellow is nature's bid to bees and insects to come and drink the nectar in the lily's cup—and pollonize the lily. The lilies that are not lovely enough to get pollonized leave no successors. Beauty of line and form and color are attributes of utility.

This great and fundamental principle operates and the steel industry has duly suffered from every violation of it. Because steel has been a uniform metal designed primarily for strength, civil engineers have drifted away from its use into the use of concrete which is often believed to resist corrosion and degenerative diseases better than steel. It is a pitiful fact that during the service life of some steel bridges, more is spent for paint to keep them from rusting away than the steel cost. The bridge might be made of corrosion resisting steel but that would cost too much. Plating with nickel, chromium, silver, copper or gold would cost too much. The only possible solution is to make steel which has low cost strength on the inside and satisfactory corrosion resistance on its surface. Steel that is uniform from center to surface is doomed by the necessities of sound design. Steel structures in which the material is of uniform strength although the stresses vary from high compression to zero to high tension will give way to structures which have low grade material where stresses are low and high grade material where stresses are high.

These, gentlemen, are some of the design changes that are ahead of us in the manufacture and use of steel.

CURRENT WELDING LITERATURE

Belts and Belting. New Belt Splicing Method. Oxy-Acetylene Tips (June 1936), vol. 15, no. 6, p. 133.

Blooming Mill. Cleaning Billet Surfaces with Oxyacetylene Flame, E. E. Thum. Metal Progress (May 1936), vol. 29, no. 5, pp. 35–38.

Bridges. Repair and Reconstruction of Metal Footbridges. Ry. Gaz. (May 1, 1936), vol. 64, no. 18, pp. 859–860. Description of various methods actually employed in repair and reconstruction work without delay to rail or foot traffic.

Bridges, Steel. Foreign Countries Lead U. S. in Welded Bridges, LaMotte Grover. Engineering News-Record (May 14, 1936), vol. 116, no. 20, pp. 703–709. Review of European accomplishments of last 5 yr. reveals many welded structures that have no counterparts as yet in American practice; special structural sections; swallow-tail splices; typical details of all-welded Vierendeel truss bridges recently designed by Belgian highway authorities; flange sections adopted by German and Swedish engineers for welded girders; field fabrication.

Bridges, Steel. Peening of Welds, LaMotte Grover. Engineering News-Record (April 30, 1936), vol. 116, p. 640.

Bronze Welding. River Buoys. Oxy-Acetylene Tips (June 1936), vol. 15, no. 6, pp. 134–135. Bronze welding lowers costs and increases production speed; operations sequence; various illustrations.

Calcium Carbide. Power and Magic of Calcium Carbide in Industry Today, B. F. Kuhl. Welding Engr. (May 1936), vol. 21, no. 5, pp. 28–31.

Coal Mines and Mining. Welding in Coal Industry. Oxy-Acetylene Tips (June 1936), vol. 15, no. 6, pp. 125–130.

Construction Equipment. Welding at Fort Peck Keeps Equipment at Work, T. B. Jefferson. Engineering News-Record (April 30, 1936), vol. 116, no. 18, pp. 624–627. Dredges, tractors, trucks, shovels and cranes receive first aid in modern welding shops operated 24 hr. a day by 115 men who are using 3 tons of welding rod weekly; selecting welding rod; wear-resistant rods; welding shops; dredge repairing; pipe-line maintenance; duplicating castings.

Diesel Engine Manufacture. Development of Welded Structures for Diesels, E. Chapman. Pac. Mar. Rev. (May 1936), vol. 33, no. 5, pp. 153–156.

Electric Welding Machines. Transformers for A.C. Arc Welding. A. E. G. Progress, no. 1, 1936, pp. 16–17.

Electric Welding, Resistance. Electronic Welding Timers, P. G. Weiller. Electronics (May 1936), vol. 9, no. 5, pp. 26–28 and 38.

Gears and Gearing Manufacture. Design and Construction of Gears and Gear Cases Employing Cast and Rolled Steel Assembled by Welding, E. Chapman. Welding Engr. (May 1936), vol. 21, no. 5, pp. 32–37.

Metals, Hard Facing. Hard Surfacing of Metals Finds Many Applications in Petroleum Industry, D. Llewellyn. Oil & Gas J. (Feb. 27, 1936), vol. 34, no. 41, p. 28.

Oil Tankers, Diesel. Largest All Welded Vessel, R. I. Ingalls, Jr., and S. C. Leigh. Pac. Mar. Rev. (May 1936), vol. 33, no. 5, pp. 160–162.

Oil Tanks. Steel Recovered from Idle Storage Is Made into Lease Tanks by Phillips, H. K. Ihrig. Oil & Gas J. (Jan. 9, 1936), vol. 34, no. 34, pp. 24–26.

Oxyacetylene Welding. Total Oxygen Requirement Determines Choice of Fuel in Steel Cutting, G. V. Slottman. Oil & Gas J. (Jan. 30, 1936), vol. 34, no. 37, pp. 52–54.

Oxy-Gas Cutting. Natural Gas for Cutting, Galvanizing and Soldering, F. Pexton. Gas Age-Rec. (Apr. 4, 1936), vol. 77, no. 14, pp. 339–340 and 346.

Petroleum Pipe Lines. Reinforcing Junction, Study of Cause Aids in Overcoming Trouble at Pipe Line Intersection, E. Sterrett. Oil Weekly (Jan. 20, 1936), vol. 80, no. 6, p. 36.

Petroleum Pipe Lines. Chronic Trouble at Pipe-Line Junction Ended by Welding, E. Sterrett. Welding Engr. (May 1936), vol. 21, no. 5, pp. 25–26.

Pipe Lines. Welding Underground Pipe Lines, H. E. Teague. Mech. World (May 1, 1936), vol. 99, no. 2574, pp. 445–446.

Pressure Vessels. Gas Welding of Class One Pressure Vessels, G. W. Plinke. Oil & Gas J. (Apr. 2, 1936), vol. 34, no. 46, pp. 33–34, 36 and 39.

Rails. Continuous Rail Lengths of Well Over a Mile. Can. Ry. & Mar. World (May 1936), pp. 191–194.

Stadiums. Design of Stadium Structures, G. Hadden. Civ. Eng. (N. Y.), vol. 6, no. 5 (May 1936), p. 328.

Steel Plates. Residual Stresses in Arc-Welded Plates, N. S. Boulton and H. E. L. Martin. Instn. Mech. Engrs.—Advance Paper, mtg. (May 31, 1936), 45 pp. Longitudinal stresses in long flat mild steel plate after depositing layer of weld metal in practically continuous run; effect on residual strains of removing deposited metal and strip; approximate theory by which residual stresses and strains may be calculated independently of measured strains; physical explanation of residual stress.

Structural Steel. Design of Welded Steel Structures Having Composite Properties, R. E. Kinkead. Welding Engr. (May 1936), vol. 21, no. 5, pp. 38–39.

Structural Steel. Welding Developments, G. A. Hughes. Iron & Steel Engr. (Sept. 1935), vol. 12, no. 9, pp. 65–69.

Tanks. Arc Welding Speeds Tank Erection. Boiler Maker & Plate Fabricator (Apr. 1936), vol. 36, no. 4, pp. 95–96.

Testing. Second Report of Welding Research Committee. Instn. Mech. Engrs.—Advance Paper mtg. April 24, 1936, 94 pp., 8 supp. plates; see also Sheet Metal Industries (May 1936), vol. 10, no. 109, pp. 409–410 and 412. Tests on welds, prepared by welding firms to specifications drawn up by Committee, carried out in condition as welded and after two heat treatments; X-ray examination; physical tests on specimens prepared from welded plates; analyses of electrodes, and welds produced from them; photomicrographs and photomacrographs of welds compared with X-ray photographs.

Valves and Valve Gears. Valve Disk Hard-Facing Methods. Oxy-Acetylene Tips (June 1936), vol. 15, no. 6, pp. 131–132.

Welding. High Speed Welding with Low Internal Stresses, A. B. Kinzel. Metal Progress (Apr. 1936), vol. 29, no. 4, pp. 56, 90, 92 and 94.

Alloys of Iron and Carbon

This monograph, the seventh in order of publication, and the sixth of the regular series, is the first portion of a correlation and critical summary of the world's knowledge on iron-carbon alloys. It was originally planned by the Iron Alloys Committee of Engineering Foundation to publish this in a single volume; it was found impossible, however, to compress the huge mass of even the most important data into a book of reasonable size; hence this seventh monograph is on constitution and heat treatment, and a later volume, now in preparation, is on properties.

Commercial iron-carbon alloys, the so-called "plain-carbon" steels and cast irons, are the most important single group of metallic materials known and constitute the bulk of the metals in use.

A list of the chapters include Iron-Carbon Alloys; General Features of the Iron–Iron Carbide Diagram; Correlation of Data for the Selected Iron–Iron Carbide Diagram; The Selected Iron–Iron Carbide Diagram; The Iron-Graphite Diagram; Arrested Transformations, Principles Underlying Hardening; Changes on Tempering Iron-Carbon Alloys; The Structure of Iron and Steel; Effect of Mass and Furance Atmosphere in Heat Treatment; Operations of Quenching, Tempering and Carburizing; Inhomogeneities in Commercial Iron-Carbon Alloys; Factors Affecting the Quality of Commercial Iron-Carbon Alloys.

The book is published by the McGraw-Hill Book Company and sells for $5.00. It comprises 476 pages with a large number of illustrations and charts.

WELDING SOCIETY ACTIVITIES AND RELATED EVENTS

TENTATIVE PROGRAM
SEVENTEENTH ANNUAL MEETING OF THE AMERICAN WELDING SOCIETY
OCTOBER 19–23, 1936
CLEVELAND, OHIO

Headquarters for Technical Sessions and Committee Meetings—Hotel Cleveland

Exposition—Cleveland Public Auditorium

Monday, October 19th

Morning

9:45 A.M. Ball Room—Business Session.
President J. J. Crowe, presiding
Report on Society Activities by President Crowe.
Teller's Report on Election of Officers.
Award of Samuel Wylie Miller Memorial Medal.
Review of Committee and Section Activities by Chairmen.
Discussion.

Afternoon

2:00 P.M. Ball Room—Technical Session.
A. E. Gibson, *Chairman*, The Wellman Engineering Company.
E. Vom Steeg, *Vice-Chairman*, General Electric Company.
Welcome address by local official.
"Fundamentals of Metallurgy of Welding," by E. S. Davenport and Dr. R. H. Aborn, United States Steel Corporation.
"Multi-Layer Oxyacetylene Pipe Welding," by R. M. Rooke, F. C. Saacke and A. N. Kugler, Air Reduction Sales Company.
High speed motion pictures of various welding processes, by E. Vom Steeg, General Electric Company; W. E. Crawford and Walter Richter, A. O. Smith Corporation.

Monday, October 19th (*Continued*)

Evening

6:30 P.M. Parlor—Dinner and Meeting Board of Directors.

Review of Society Activities, appointment of committees and officers, new business.

Tuesday, October 20th

Morning

9:45 A.M. Ball Room—Technical Session.

H. M. Boylston, *Chairman*, Case School of Applied Science.

E. R. Fish, *Vice-Chairman*, The Hartford Steam Boiler Inspection & Insurance Company.

FUNDAMENTAL RESEARCH IN WELDING

"Heating by the Proximity Effect," by Edward Bennett, The University of Wisconsin.

"The Welding of Copper," by A. P. Young, Michigan College of Mining and Technology.

"Non-Destructive Testing of Welds," by W. B. Kouwenhoven, The Johns Hopkins University.

"Impact Tests of Welds at Low Temperatures," by Otto Henry, Brooklyn Polytechnic Institute.

Afternoon

2:00 P.M. Ball Room—Technical Session.

H. W. Gillett, *Chairman*, Battelle Memorial Institute.

R. E. Kinkead, *Vice-Chairman*, Consulting Engineer.

FUNDAMENTAL RESEARCH IN WELDING

"X-Ray Methods for Studying Stress Relief," by John T. Norton, Massachusetts Institute of Technology.

"Welded Beam-Column Connections," by Inge Lyse, Fritz Engineering Laboratory, Lehigh University.

"Circuit Characteristics and Arc Stability," by S. C. Osborne, Wilson Welder and Metals Co., Inc.

"Welded Structural Brackets," by C. D. Jensen, Lehigh University.

Evening

7:30 P.M. Conference and Meeting of Fundamental Research Committee, Bureau of Welding Research and Engineering Foundation.

H. M. Hobart, *Chairman*, General Electric Company.

This conference is scheduled for university research workers in the fundamentals of welding.

Wednesday, October 21st

Morning

9:45 A.M. Ball Room—Technical Session.

A. F. Davis, *Chairman*, The Lincoln Electric Company.

C. A. McCune, *Vice-Chairman*, Magnaflux Corporation.

"Brazing with Silver Solders," by Robert H. Leach, Handy & Harman.

"Importance of Design Control for Welded Piping Systems," by T. W. Greene, Linde Air Products Company.

"Principles of Surfacing by Welding," by E. W. P. Smith, The Lincoln Electric Company.

"Technique for Resistance Welding Ferrous and Non-Ferrous Sheet Metals," by E. I. Larsen, P. R. Mallory Co.

Afternoon

2:00 P.M. Ball Room—Technical Session.

Hugh H. Dyar, *Chairman*, The Linde Air Products Company.

J. B. Tinnon, *Vice-Chairman*, Metal and Thermit Corporation.

"Procedures for Control of Welding Parts," by G. H. Moore, Jr., Newport News Shipbuilding and Dry Dock Company.

"Welding Copper and Its Alloys—A Review of the Literature," by Ira T. Hook, American Brass Company.

"Resistance Welding of Dissimilar Metals," by R. T. Gillette, General Electric Co.

"Thermit Welding," by J. H. Deppeler, Metal & Thermit Corporation.

"The Exploration of the Modern Metallic Arc," by L. J. Larson, A. O. Smith Corporation.

Evening

8:00 P.M. Stag—Entertainment, Beer and Pretzels.

Thursday, October 22nd

Morning

9:45 A.M. Joint Session American Welding Society with American Society of Mechanical Engineers.

C. W. Obert, *Chairman*, Union Carbide & Carbon Research Labs., Inc.

Milton Male, *Vice-Chairman*, United States Steel Corporation.

"Stress Analysis," by C. H. Jennings, Westinghouse Elec. & Mfg. Co.

"Alloy Steels and Their Weldability," by A. B. Kinzel, Union Carbide and Carbon Research Labs.

Afternoon

2:00 P.M. Joint Session American Welding Society with American Society of Mechanical Engineers.

H. F. Henriques, *Chairman*, Air Reduction Sales Company.

S. M. Weckstein, *Vice-Chairman*, Timken Roller Bearing Company.

"Welding Heavy Machinery and Equipment," by C. A. Wills and F. L. Lindemuth, Wm. B. Pollock Company.

"Steel Plate Construction."

"Using Steel Plates for Machine Frames."

Evening

7:00 P.M. Dinner dance with entertainment.

Friday, October 23rd

Morning

American Society of Mechanical Engineers
(AMERICAN WELDING SOCIETY members invited)

Weldability of Non-Ferrous Metals:
Copper, Brass and Bronze, Monel Metal, Aluminum.

Afternoon

American Society of Mechanical Engineers
(AMERICAN WELDING SOCIETY members invited)

Review of Welding Developments as they affect Mechanical Design.

Welding of Light Machines and Products.

Principles Involved in Selecting Casting *vs.* Welding.

Metal Congress Exposition, Public Auditorium, Cleveland, October 19 to 24, 1936.

The Welding Industry

We believe our members would be very much interested in a letter received from one of our newly elected Sustaining Members.

MODERN MACHINE SHOP

Published by Gardner Publications, Inc.

CINCINNATI

June 8, 1936.

Mr. A. F. Davis, Vice-President,
The Lincoln Electric Company,
East 131st and Coil Road,
Cleveland, Ohio.

Dear Mr. Davis:

Enclosed is check for $100.00, along with our application for a Sustaining Membership in the AMERICAN WELDING SOCIETY.

Both Mr. Howard Campbell, Editor, and I feel as tho there is an exceptionally bright future for the Welding Industry and that it will continue to expand in a substantial manner during the years to come.

It really isn't necessary for me to mention to you in passing that we have devoted a considerable amount of editorial space to the promotion of welding in its various forms, and will continue to do so in coming issues of MODERN MACHINE SHOP.

My very best wishes to you.

Sincerely yours,
(Signed) Don G. Gardner
President

Midwest Welding Conference

The Midwest Welding Conference, which was held in Chicago June 4th, 5th and 6th, drew an attendance of over 1500 people, about 90% of whom were actively engaged in some phase of welding.

For the most part these visitors came from Chicago and environs, but there were many registrations from Milwaukee, Minneapolis, Omaha, St. Louis, Indianapolis, Cleveland, Pittsburgh and New York. Perhaps the man who traveled the farthest to come to this Conference was Mr. Henry Ploss, of Essen, Germany.

Among the papers given were:

"Arc Welding Costs Reduced by Cross Field Principle," Mr. J. H. Blankenbuehler, Design Engineer, Westinghouse Electric & Mfg. Co.

"Recent Improvements in Shielded Arc Welding and Its Application," Mr. A. M. Candy, Consulting Engineer, Hollup Corp.

"Application of Electric Welding to the Railroads," Mr. E. E. Wanamaker, Elec. Eng., C. R. I. & P. R. R.

"Application of Bronze Welding and Brazing to Railroad Shops," Mr. Homer Gannett, Welding Supervisor, C. B. & Q. R. R.

"New Developments in Steel Welding," Mr. Thomas Jones, Welding Supt., Carnegie-Illinois Steel Co.

"Hard Surfacing and Welding of Manganese Steel," Mr. E. L. Quinn, Welding Engineer, Am. Manganese Steel Co.

"Welding Nickel, Monel Metal and Inconel," Mr. F. G. Flocke, Welding Engineer, International Nickel Co.

"Interesting New Developments in the Arc Welding Industry," Mr. W. W. Reddie, Engineer, Westinghouse Elec. & Mfg. Co.

Illustrated talk on "Applications of Low Alloy Steels for Special Purposes," Mr. Louis J. Larson, A. O. Smith Corporation.

"The Control of Expansion and Contraction by Local Heating in Cast-Iron Parts," Mr. Roy Peterson, Bronze Welding Engineer, Burdett Oxygen and Hydrogen Co.

"Automatic Shape Cutting," Mr. J. F. Olson, Engineer, Burdett Oxygen and Hydrogen Co.

"Phos-Copper," Mr. E. A. Randall, Service Engineer, Burdett Oxygen and Hydrogen Co.

The Railway Session on Friday afternoon was probably the best attended meeting. Aside from scheduled talks several men prominent in railway circles joined in the discussions.

The spectators proved to be keenly interested in the various demonstrations of arc welding, gas welding, gas cutting, metal spraying, rail end welding, brazing, hard surfacing and related subjects. The sponsors reported an unusual amount of interest in their respective parts.

The Conference was planned to enable every person in attendance to get the specific information he was seeking. Not only were there question and answer periods at the conclusion of each speaking session, but a question box was also used. The questions of numerous visitors placed in the box were answered twice each day over the public address system.

The sponsors of this Conference were:

Hollup Corporation in cooperation with:
American Brass Company,
American Manganese Steel Company,
American Steel & Wire Company,
Burdett Oxygen & Hydrogen Company,
The International Nickel Company,
Westinghouse Elec. & Mfg. Company,
The Welding Engineer.

Specifications for Bridges

(Reprinted from July 4, 1936, issue Railway Age)

The appearance of this treatise marks the beginning of a new chapter in the history of fusion welding in America. It demonstrates that the advance of the art in this field has arrived at a stage that permits of definite agreement concerning fundamental principles of design and practices by a committee of engineers representing the leading interests in this field, including four railway bridge engineers of whom P. G. Lang, Jr., of the Baltimore & Ohio, served as chairman. The book represents the results of two years of intensive work that embraced a study of the relevant literature of foreign countries as well as the United States, in addition to the investigation of current practice and available test data.

While a large part of the text is in the form of mandatory clauses, the committee has seen fit to present its views in a foreword on the limitations of the process and the responsibilities imposed on those who apply it, as well as a discussion of unit stresses that serves as a basis for the mandatory clauses relating to design. In addition to design, the specifications cover equipment, materials and workmanship, the technic of arc and gas welding, and the testing of welding work and the qualifications of welders. The sections on definitions and symbols should go a long way to bring about greater uniformity in the special terminology of this new art.

Obituary

The Society announces with a great deal of regret the death of Ferdinand W. Roebling, Jr., President of John A. Roebling's Sons Company, on Friday, May 29th.

The J. A. Roebling's Sons Company has been one of the Sustaining Company Members since the inception of the AMERICAN WELDING SOCIETY.

SECTION ACTIVITIES

CHICAGO

The following Officers and Directors were elected by the Chicago Section:

Chairman—Albert Reichmann
Vice-Chairman—Tom Jones
Secretary-Treasurer—F. L. Spangler
Directors for Three Years—J. Kinsock, Leslie McPhee, G. E. Tenney, D. C. Wright
Director for one year to fill vacancy—A. M. Candy
Director to represent the Chicago Section on National Board of Directors—C. J. McGregor

LOS ANGELES

The regular meeting was held on May 28th at the Los Angeles Chamber of Commerce Building. Thirty-four members and guests were present. Dinner was served at 6:30 P.M., after which the meeting was called to order by Vice-Chairman Wayne Howard.

Mr. H. P. Vail, Distribution Division Engineer of the Metropolitan Water District, gave an extremely interesting talk on the fundamental problems and their solution in forwarding this project. His talk was supplemented by a colorful talking picture and many stereopticon slides.

Mr. C. P. Sander, General Superintendent of the Western Pipe and Steel Co., gave an interesting impromptu talk on construction of steel and concrete pipe for the Metropolitan Aqueduct.

The regular June meeting was held on the 25th at the Los Angeles Chamber of Commerce Building with seventy members and guests present. Dinner was served at 6:30 P.M., after which the meeting was called to order by Chairman J. C. Blake, and guests were introduced.

The first speaker was Mr. C. A. McCune, Secretary, Magnaflux Corporation, New York City. He was introduced by Mr. C. J. Nyquist, who gave a colorful history of the speaker's contributions to welding and his services to the AMERICAN WELDING SOCIETY. Mr. McCune gave an exceptionally interesting talk on "Non-Destructive Testing of Welds." His talk was augmented by stereopticon slides. He also demonstrated his method of testing on several samples of faulty steel parts. Extensive discussion followed this talk and reflected the interest aroused by the speaker.

The second speaker, Mr. Robert A. Kunkler, Sales Engineer, Metalizing Company of America, described "Sprayed Metal Coatings" and their application for corrosion protection, ornamentation and building up worn shafts and parts. A motion picture illustrated the processes and applications described by the speaker.

The chairman announced that the next meeting of the section will be held in September.

NORTHERN NEW YORK

The following are a list of Officers, Directors and Committees for 1936–37 of the Northern New York Section:

Chairman—J. E. Waugh
1st Vice-Chairman—W. F. Hess
2nd Vice-Chairman—F. H. Miller
Secretary-Treasurer—R. W. Clark
Director at Large—L. R. Leveen

Directors

J. J. Weldon — Terms ending May 31, 1937
E. J. Edwards

R. T. Gillette — Terms ending May 31, 1938
A. G. Cochrane
M. Unger — Terms ending May 31, 1939
R. L. Browne

Membership Committee
Chairman—F. H. Miller
C. G. Somerville, W. W. Churchill, W. F. Hess, C. Grumen, E. J. Edwards, R. C. Willey, L. R. Leveen

Meetings and Papers Committee
Chairman—R. W. Clark
W. F. Hess, E. F. Potter, J. J. Weldon, A. S. Binek, O. A. Tilton

Public Relations Committee
Chairman—L. D. Meeker
L. R. Leveen, A. Vogel

Engineering Coordinating Committee Representative
R. W. Clark, *Chairman*, Meetings and Papers Committee

SAN FRANCISCO

The May meeting was held on the 29th and was preceded by a dinner. Chairman E. L. Mathy appointed a committee designated as a "Practical Applications Committee" consisting of

Jean LaForce, Linde Air Products Company
C. E. Grant, Air Reduction Sales Company
Mr. Henderson, Lincoln Electric Welding Co.
C. E. Owens, General Electric Co.

The duties of the committee as outlined would be to answer questions on practical applications. These questions are to be considered in writing and answered at a subsequent meeting.

Mr. V. L. Holdaway, Chief Engineer of the Steel Tank and Piping Company, Berkeley, gave a very interesting talk on hand and automatic welding from sheet to spun pipe.

Mr. K. V. King, Chief Engineer of the Standard Oil Company of California, discussed the AMERICAN WELDING SOCIETY JOURNAL and its real value to those interested in welding. Mr. King reviewed in detail the articles appearing in the April and May issues. He pointed out that the article on Impact Tests of Welds was an excellent article which should be read and filed for future use by all interested in welding. In connection with the May issue Mr. King stressed the value of the articles relating to Low Alloy Steels and their importance to the industry.

Mr. H. A. Storrs, Chief Inspector of the East Bay Municipal Utility District, read a paper on the Mokelumne pipe line.

The June meeting was held on the 26th at the plant of the Western Pipe & Steel Co., South San Francisco. After dinner, Mr. K. V. King presented a brief résumé of current welding literature. Mr. T. R. Rooney, Plant Superintendent of Western Pipe & Steel Co., spoke on the subject "Automatic Welding of Large Diameter Pipe." This was followed by a tour through the plant where many interesting operations were explained by Mr. Rooney.

SPECIFICATIONS FOR DESIGN, CONSTRUCTION, ALTERATION AND REPAIR OF HIGHWAY AND RAILROAD BRIDGES BY FUSION WELDING
NOW AVAILABLE!
PRICE $1.00
Price to Members AMERICAN WELDING SOCIETY 75¢
66 Pages - - - 19 Illustrations
AMERICAN WELDING SOCIETY
33 WEST 39th STREET NEW YORK

"ANTI-BORAX"
Oxy-Acetylene Welding and Brazing
FLUXES
Are Unequaled for Quality
A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; "Anti-Borax" Tinning Compound No. 11.
Send for Free Samples
ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

1935 BOUND VOLUME
Bound Volumes of the JOURNAL of the Society for the year 1935 are now available with imitation black leather covers. Contains a wealth of information on the latest developments in welding. Also contains Subject and Authors' Index. Price, $5.00 plus postage to members; $6.50 to non-members.

East Engin.
SEP 11 1936

BUSINESS or pleasure may take you along strange roads and to strange places. But the lines to home are never broken. Day and night—north, south, east and west—you are in touch by telephone.

The privilege of talking with almost any one, any time, anywhere is distinctly American. Service in this country is not limited to large cities, thickly populated centers or certain hours of the day.

Of the 34,000,000 telephones in the world, more than 50% are in the United States—connected with the Bell telephone in your home or office.

This country also leads in the number of telephones in relation to population, with 13 for every hundred people. The average for Europe is less than three.

Universal service in this country did not just happen. It has been made possible by the development of the Bell System over the past half-century.

BELL TELEPHONE SYSTEM

Our Advertisers Are Supporting the Society